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APPLIED MECHANICS REVIEWS

VOL. 5, NO. 2 **MARTIN GOLAND** *Editor* FEBRUARY, 1952

PRESENT-DAY TRENDS IN HYDRAULICS

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UNTIL the beginning of the twentieth century, hydraulics was essentially the only engineering science dealing with fluid motion. For various reasons associated with its historical background, however, its underlying principles were not sufficiently general for application to the many new professional fields which have since developed. Instead, it became necessary to correlate the mathematical methods of classical hydrodynamics with systematic experimental investigations in both old and new fields of flow, thus establishing the more broadly useful science known today as the mechanics of fluids.

Like other old and conservative philosophies, hydraulics at first remained unaffected by the comparatively rapid progress being made around it, and only gradually did it begin to absorb such aspects of the broader principles as seemed directly useful. Within the past two decades this process of reorientation finally progressed to the point that the parent science is now not only taking good advantage of advancements made in the general subject of fluid motion but also is contributing its proper share. In fact, one can no longer delineate clearly the borders of hydraulics, since there is an almost continuous transition into allied sciences on every side. The following résumé of present-day tendencies is therefore restricted arbitrarily to those phases which have long been the principal lines of hydraulic endeavor.

Acceptance of the theory of potential flow well illustrates current trends. One of the original issues between classical hydrodynamics and empirical hydraulics arose from the fact that such mathematical theories were most nearly applicable to flow past streamlined boundaries, whereas hydraulic structures as a rule were poorly faired—and hence hardly susceptible to analytical design. However, requirements of high efficiency, absence of cavitation, and freedom from eddy-induced vibration in the costly structures of today are forcing the adoption of streamlining as an economic necessity. Potential theory is hence becoming an invaluable tool—as witness its application to the planning of conduit inlets, spillway crests, and other transitions, with the method of relaxation and the three-dimensional electrical analogy being used to a steadily increasing degree. While the same potential theories and methods had previously been applied with success to the flow of ground water, these have now been extended to flow in three dimensions and, at least two-dimensionally, to conditions of soil stratification.

Wave motion, long the only phase of free-surface hydraulics subjected to mathematical treatment, has maintained its lead in this manner of approach. Initial studies of the solitary wave and the deep-water wave have been enlarged to include the entire range between these limits. Such inherently unsteady phenomena as seiche and breaking waves, as well as the viscous dissipation of wave energy, are becoming steadily better understood. Interest in conditions of density stratification due to sediment suspension, temperature variation, or salt-water intrusion has gradually led to the investigation of subsurface waves and currents. The analogy between sound waves and gravity waves has permitted improvements in methods of designing high-velocity channels; in fact, use of the analogy has now gone full circle, in that wave flumes have become exploratory adjuncts to supersonic wind tunnels. Finally, the development of both mechanical and electrical analyzers has enabled great progress to be made in the study of flood-wave propagation. Water hammer—the closed-conduit counterpart of surface-wave hydraulics—was analyzed so effectively during the first quarter of the present century that efforts during the past two decades have been centered largely upon the application of the analysis to complex systems and conditions of wave generation; because of its great rapidity of solution, the electronic analog computer is proving to be of value in this regard.

In problems of conduit resistance, hydraulics has only begun to regain the position of leadership which it lost when the Reynolds-number concept, the boundary-layer theory, and the so-called universal laws of velocity distribution and resistance were originated in other scientific fields. As in the past, interest continues to be focused upon the resistance of rough surfaces, with particular attention to the natural roughness of new and aged commercial materials. Although average trends and values are now well defined, much remains to be accomplished in the statistical analysis of roughness and the prediction therefrom of its hydraulic behavior. Boundary-layer principles are slowly taking their place in the approach to such problems as cavitation at wall irregularities, establishment of flow in steep chutes, and fluid metering, with promise of considerable future success.

In matters of fluid turbulence, the tendency is still toward application of the simpler concepts developed in the not-too-recent past rather than contribution to current theoretical analysis. One of the principal obstacles to rapid progress is the fact that most turbulence in hydraulics is of the nonisotropic type, with wake and jet flow playing major roles, whereas existing theories of a practicable sort deal almost exclusively with conditions of isotropy. Problems of turbulence especially hydraulic in nature include eddy cavitation, the entrainment of air by high-velocity flow, the turbulent diffusion of material carried in suspension, and the mixing of stratified currents. In each of these problems there is now marked investigational activity.

Also peculiar to hydraulics in both historical background and present importance is the very complex problem of sediment transportation. Analysis of the settling of individual particles and particle groups through fluids has recently been extended over a considerable range of particle shape, concentration, and Reynolds number. The suspension phase of transport is understood in at least its basic aspects—up to the familiar point of distinction between momentum diffusion and mass diffusion, or the evaluation of the effect of the suspended material upon the flow itself. Bed-load movement remains in its empirical stage of evaluation, but gradual progress is being made. As in other phases of turbulent diffusion, the primary link in the chain of analysis which still remains to be forged is the necessary relation between the concentration of material in the flow just above the bed to that in the bed itself.

Because of its highly industrialized aspects, progress in the field of hydraulic machinery is somewhat difficult to segregate into its scientific and its engineering parts. Perhaps the greatest forward stride from the viewpoint of science as a whole has been the tendency to uniformalize the analysis of all turbomachinery, regardless of the fluid medium in question. Some progress—necessarily of a qualitative rather than a quantitative nature—has been made in the application of conformal methods to the control of blade design. Attention has also been given to the behavior of turbomachinery over a considerable Reynolds-number range. The commercial demand for high-pressure positive-displacement machinery has begun to stimulate analytical as well as purely developmental activity in both this field and the closely related one of hydraulic controls.

Hydraulics laboratories have played a considerable role during the present century in advancing the technique of scale-model investigations. An unsolved problem of long standing is the dependable simulation of river flow at reduced scale over movable beds of sediment, particularly under conditions of vertical (not to mention sedimentary) distortion. Of somewhat more recent importance is the simulation of the mixing produced by gravity underflows in reservoirs and tidal estuaries. The use of air for convenience in the study of many phenomena of hydraulics which do not involve a free surface is a noteworthy trend of the past decade. Quite recently the development of high-speed movie photography has permitted the detailed observation of such rapid occurrences as the growth and collapse of cavitation bubbles. Hydraulic instrumentation has also taken advantage of recent progress in electronics, but—despite good exploratory advances in the application of electrical methods to the measurement of liquid turbulence—a generally useful tool comparable to the hot-wire anemometer is yet to be perfected.

Hydraulic research as such is centered primarily in the university laboratories of the western countries, the strong position of leadership taken by the German institutions between World Wars I and II now being shared by various European countries and the United States. National laboratories, though restricted largely to the solution of specific problems, have contributed since the beginning of World War II to various aspects of instrumentation and fundamental knowledge as an outgrowth of their developmental projects, and governmental as well as private agencies are promoting university activity through provision of research funds.

Because of the great range of subject matter encompassed by this review, the selection of a few representative papers to highlight trends in the many different phases of hydraulics is hardly feasible. Instead, reference is made to Jaeger's "Technische Hydraulik" (AMR **3**, Rev. 712), and to the symposium volume, "Engineering Hydraulics" (AMR **4**, Rev. 1207), for résumés of present-day principles and their application and for the extensive bibliographies contained therein. Details of current investigations will be found in the annual summary, "Hydraulic Research in the United States," distributed by the National Bureau of Standards, and in a similar publication of the International Association for Hydraulic Research.

APPLIED MECHANICS EXPERTS PREPARE FOR EIGHTH INTERNATIONAL CONGRESS

Scientists and engineers working in the field of applied mechanics are looking forward to the Eighth International Congress for Applied Mechanics to be held at the University of Istanbul, Istanbul, Turkey, August 20 to 28, 1952. The Congress combines the opportunity of personal contacts with scientists and engineers from many nations, representing the leading centers of research in elasticity and plasticity, fluid mechanics, mechanics of solids, and heat transfer, with a visit to a beautiful historic city in a country of world-wide interest today.

The First International Congress was held in 1924 at Delft, Netherlands, following a preliminary meeting in 1922 at Innsbruck, Austria, organized by Theodore von Kármán. Except for the war period, meetings have been held at four-year intervals, at Zürich in 1926, Stockholm in 1930, Cambridge, England, in 1934, Cambridge, Massachusetts, in 1938, Paris in 1946, and London in 1948. In most cases, Proceedings have been published which constitute valuable reviews of the state of knowledge at the time. The Congress is a voluntary association of individual scientists organized every four years by a local committee named by a continuing International Committee. U. S. members of the International Committee are H. L. Dryden, J. C. Hunsaker, Th. von Kármán, and S. Timoshenko. The Applied Mechanics Division of The American Society of Mechanical Engineers since its formation in 1928 has always taken an active part in co-operating with the International Committee. American participation in the Eighth Congress is being organized, with H. L. Dryden as chairman, and C. E. Davies as secretary, by the U. S. National Committee on Theoretical and Applied Mechanics, a joint committee represented by The American Society of Mechanical Engineers, American Institute of Chemical Engineers, Society for Experimental Stress Analysis, American Society of Civil Engineers, Institute of the Aeronautical Sciences, American Mathematical Society, and American Physical Society.

Membership in the Congress is open to all individuals interested in applied mechanics. Each member may present two fifteen-minute papers. Abstracts not exceeding 400 words in length must be submitted not later than June 1, 1952, on forms which may be secured from the Secretary of the Congress: Sekizinci Enternasyonal Teorik ve Tatbiki Mekanik Kongresi, P. K. 245, Istanbul, Turkey. The Congress will meet in five sections as follows: I, Elasticity, Plasticity, Rheology; II, Fluid Mechanics (Aerodynamics, Hydrodynamics); III, Mechanics of Solids (Ballistics, Vibrations, Friction, Lubrication); IV, Statistical Mechanics, Thermodynamics, Heat Transfer; V, Mathematics of Physics and Mechanics, Methods of Computation. The Proceedings will be published, including invited addresses and lectures by a few outstanding scientists and engineers.

There will be many interesting social and entertainment features, including receptions by the Rector of the University of Istanbul and by the Governor and Mayor of Istanbul, and the official dinner which all members of the Congress are entitled to attend. Visits will be arranged to the Old Seraglio, Museum of

Antiquities, Museum of Ancient Orient, famous churches and mosques such as the Mosque of Soliman the Magnificent, the Grand Bazaar, and similar places of interest as well as a sea excursion up the Bosporus to the entrance of the Black Sea.

In view of the high demand for travel services in Europe, sea and air transportation will be heavily booked during the summer and autumn of 1952. It is therefore important that prospective Congress members arrange their transportation at their earliest convenience.

The American Express Company, as the official travel agency of the Congress, offers the following tours which in the opinion of the U. S. National Committee meet the needs of most U. S. participants:

Tour A: Air transportation for those with limited time.

Leave New York on Saturday, August 16, to Rome via TWA, thence to Istanbul via BEA, arriving August 18. Returning from Istanbul on Friday, August 29, arriving in New York on Sunday, August 31. Approximate all-expense cost, $1318 or, alternately, if air-coach rates are applicable, $1048.

Tour B: For those desiring additional sightseeing in Italy.

Leave New York on Wednesday, August 6, via *S. S. Constitution* (American Export Lines) for Naples, calling at Gibraltar and Cannes. Sightseeing Naples and Rome. Rome to Istanbul via BEA, arriving August 19. Returning from Istanbul on Saturday, August 30, via BEA to Rome. Sightseeing Florence, Venice, Genoa. Sail from Genoa on Sunday, September 7, via *S. S. Constitution*, arriving New York on Monday, September 15. Approximate all-expense cost: minimum first class $1355, minimum cabin class $1220, minimum tourist class $1115.

Tour C: Same as Tour B, except air travel.

Leave New York on Thursday, August 14, joining Tour B at Naples. Returning, leave Venice on Friday, September 5, to Milan, thence to New York, arriving on Saturday, September 6. Approximate all-expense cost, $1486 or, alternately, if air-coach rates are applicable, $1216.

Individual tours to meet special requirements may be arranged. For details write to the American Express Company, 624 Fourteenth Street, N. W., Washington, D. C., U. S. A.

Communications

Concerning AMR 4, Rev. 4119 (November 1951):

Lines 2 and 3 should read: "...author uses an octagonal tower subjected to wind load."

Concerning AMR 4, Rev. 2863 (July 1951): R. A. Clark and E. Reissner, Deformations and stresses in Bourdon tubes.

In amplification of Rev. 2863, the theoretical results of Clark and Reissner for Bourdon tubes with elliptical cross sections show a marked difference (about double the value) in comparison with (unpublished) measurements, made 1940 by a reviewer's former collaborator in the spring laboratory of Schäffer and Budenberg, Ltd. (Germany). The measurements were undertaken with tubes, drawn with drawing dies of tungsten carbide possessing an elliptically grinded hole. The usually manufactured Bourdon tubes have no elliptical cross section, but for convenience sake, have a cross section consisting of two parallel walls and two half circles. The theory of these tubes is known and was found to be in excellent accordance with measurements. The new results of Reissner and Clark would indicate an extraordinarily great influence of the form and would mean that Bourdon tubes of elliptical cross section have much more sensitivity than the usually manufactured. There seems to be a technical interest in thoroughly investigating this question also with experimental methods, in order to decide whether the previous measurements or the new theoretical results are justified. The reviewer wishes to say that he did not intend to criticize the mathematical correctness of the Reissner-Clark theory when mentioning the contradicting previous measurements. Walter Wuest, Germany

Theoretical and Experimental Methods

(See also Revs. 377, 464, 476)

322. Ludwig, R., Graphical integration method for Meissner's line graphs in differential equations of first order (in German), *Z. angew. Math. Mech.* **31**, 6, 169–178, June 1951.

Meissner line graphs, a construction consisting only of straight lines, have been applied elsewhere to the evaluation of definite integrals and to the solution of differential equations of the second and higher order. This method is not directly applicable to the solution of first-order equations. A construction involving a rapidly convergent iteration procedure, developed by synthesis from the method for definite integrals, is described by the author. However, so many pertinent details are assumed to be known from a preceding paper by the author that the paper at hand cannot be considered a complete entity but must be read in conjunction with the earlier paper [title source, **31**, 120–130, 1951].

Several possible approaches to the problem of graphical integration are outlined briefly. Each apparently has its own field of application, and author states the conditions which govern the choice of method. In addition, he indicates a way in which an estimate of the error may be obtained. This latter is a step which is omitted in most graphical methods. Finally, the paper gives, in tabular form, a synopsis of the successive steps to be taken in solving a differential equation of the first order using this new method. J. R. Bruggeman, USA

323. O'Brien, G. G., Hyman, M. A., and Kaplan, S., A study of the numerical solution of partial differential equations, *J. Math. Phys.* **29**, 4, 223–251, 1951.

Authors present in a systematic and unified manner a discussion of methods developed in recent years for the analysis and improvement of the stability characteristics (error growth) of finite difference equations used in the numerical solution of systems of partial differential equations. There is also a discussion of the convergence of the solutions of finite difference equations to the solutions of the corresponding differential equations. A method of stability analysis, due primarily to J. von Neumann, is discussed in detail and is applied to several basic types of equations. The simplest form of the heat-conduction equation [1] $\partial\phi/\partial t = \partial^2\phi/\partial x^2$, is used to illustrate the difficulties which may be encountered in carrying out the numerical solution of partial differential equations, unless a preliminary analysis is carried out. The following three equivalent difference forms are considered:

$$[\phi(x,t+\Delta t) - \phi(x,t-\Delta t)]/2\Delta t = [\phi(x+\Delta x,t) - 2\phi(x,t) + \phi(x-\Delta x,t)]/(\Delta x)^2 \quad [2]$$

$$[\phi(x,t+\Delta t) - \phi(x,t)]/\Delta t = [\phi(x+\Delta x,t) - 2\phi(x,t) + \phi(x-\Delta x,t)]/(\Delta x)^2 \quad [3]$$

$$[\phi(x,t+\Delta t) - \phi(x,t)]/\Delta t = {}^1/_2(\Delta x)^2 \{[\phi(x+\Delta x,t+\Delta t) - 2\phi(x,t+\Delta t) + \phi(x-\Delta x,t+\Delta t)] + [\phi(x+\Delta x,t) - 2\phi(x,t) + \phi(x-\Delta x,t)]\} \quad [4]$$

Form [2] was used by L. F. Richardson and proves to be un-

stable for all values of $\Delta t/(\Delta x)^2$. Form [3] gives useful results only in case the inequality $\Delta t/(\Delta x)^2 \leqslant {}^1/_2$ is satisfied. Form [4] is due to J. von Neumann and D. R. Hartree and gives stable results for all value of $\Delta t/(\Delta x)^2$. The discussions are supplemented by extensive numerical examples. The material should prove to be of considerable value in the practical solution of partial differential equations (by finite difference methods) on high-speed digital calculators. H. Polachek, USA

324. Zachrisson, L. E., On the membrane analogy of torsion and its use in a simple apparatus, *Trans. roy. Inst. Technol. Stockholm* no. 44, 39 pp., 1951.

Author presents clear detailed account of classical torsion theory and the membrane analogy. He then shows how it is possible to utilize the analogy experimentally by measuring slopes along the boundary only, thus dispensing with the customary reference bubble and elevation measurements. Simple apparatus and procedure are thoroughly described. Results are presented for the semicircular cross section and the circular section with eccentric circular cavity. Values obtained for maximum stress showed errors generally less than 3%.

Theodore Andreopoulos, USA

325. Cameron, J. M., and Youden, W. J., The selection of a limited number from many possible conditioning treatments for alloys to achieve best coverage and statistical evaluation, *Proc. Amer. Soc. Test. Mat.* **50,** 951–960, 1950.

Stress-rupture data present special problems because the number of conditioning factors preclude exhaustive exploration of all combinations of these factors, and the test results necessarily involve different test temperatures and loads so that the hours to rupture of specimens from different conditioning treatments are not directly comparable. Paper gives a method for comparing test results and considers the planned selection of combinations of conditioning factors for testing with a view to facilitating the statistical analysis. From authors' summary

⊛326. Wade, T. L., The algebra of vectors and matrices, Cambridge, Mass., Addison-Wesley Press, Inc., 1951, ix + 189 pp.

Author has expanded course material used at Florida State University, presupposing only elementary analytic geometry and some theory of determinants. Such a text was long overdue. After defining concepts of groups, fields, and rings, which are subsequently illustrated rather than used, author introduces usual algebraic theorems of vectors in two and three dimensions before passing to n dimensions. Matrixes enter in chapter 5, followed in the next chapter by inverse and adjoint, Cramer's rule, and orthogonal matrixes. Chapter 7 is on groups, matrixes, and transformations, and chapter 8 on characteristic equations and vectors. Two chapters follow on rank, Laplace's development, equivalent and congruent matrixes, and bilinear forms, while a final chapter of six pages lists some applications. Numerical examples and exercises illustrate the concepts abundantly.

A. S. Householder, USA

327. Nickel, K., Solution of a system of integral equations from the theory of lifting surfaces (in German), *Math. Z.* **54,** 81–96, 1951.

Author considers the integral equation

$$\frac{1}{\pi}\sum_{\nu=1}^{n}\int_{a_\nu}^{b_\nu}\frac{f_\nu(y_\nu)}{x_\mu - y_\nu}\,dy_\nu = g_\mu(x_\mu), \quad \mu = 1, \ldots, n, \qquad [1]$$

where $a_1 \leqq x_1 \leqq b_1 < a_2 \leqq \ldots < a_n \leqq x_n \leqq b_n$, and the Cauchy principal value is to be taken. It is assumed that the $g_\mu(x)$ are measurable for $a_\mu \leqq x \leqq b_\mu$ and that

$$\int_{a_\nu}^{b_\nu} |g_\nu(x)|^p[(b_\nu - x)(x - a_\nu)]^{1/2(p-1)}dx$$

exists for $\nu = 1, \ldots, n$. Author shows that the most general solution of [1] is

$$f_\nu[y_\nu] = -\frac{(-1)^\nu}{\pi}[-\mathbf{II}_\kappa(b_\kappa - y_\nu)(a_\kappa - y_\nu)]^{-1/2}$$

$$\times\left\{\sum_{\mu=1}^{n}(-1)^\mu\int_{a_\mu}^{b_\mu}\frac{g_\mu(x)}{y_\nu - x}\right.$$

$$\left.[-\mathbf{II}_\lambda(b_\lambda - x)(a_\lambda - x)]^{1/2}dx + P_{n-1}(y_\nu)\right\}$$

$a_\nu \leqq y_\nu \leqq b_\nu$, $\nu = 1, \ldots, n$, where

$$P_{n-1}(y) = A_{n-1}y^{n-1} + \ldots + A_1 y + A_0$$

has arbitrary coefficients and $A_{n-1} = (-1)^{n-1}\Sigma_\nu\int_{a_\nu}^{b_\nu}f_\nu(x)dx$. The proof is by induction on n, the proof for $n = 1$ having been established in an earlier paper [title source, **53**, 21–52, 1950]. Author's statement that only the cases $n = 1$ and 2 had been considered previously overlooks the fact that similar theorems can be found in the work of Muskhelishvili [e.g., "Singular integral equations. . .," Moscow-Leningrad, OGIZ, 1946, especially §88]; or of Mikhlin ["Integral equations. . .," 2nd ed., Moscow-Leningrad, OGIZ, 1949, §27]. J. V. Wehausen, USA

⊛328. Levin, V. I., and Grosberg, Yu. I., Differential equations of mathematical physics [Differentsial'nîe uravneniya matematicheskoĭ fiziki], Moscow-Leningrad, Gosudarst. Izdat. Tekh.-Teor. Lit., 1951, 575 pp.

This textbook is intended for engineering students. Chapter headings are as follows: I. Statement of several fundamental problems of mathematical physics; II. Theory of the potential; III. The wave equation in an unbounded region; the method of characteristics; IV. Problems in characteristic functions; V. Solution of problems of mathematical physics by the method of characteristic functions; Appendix: Fundamental facts from the theory of cylinder functions.

Courtesy of Mathematical Reviews

⊛329. Sobolev, S. L., The equations of mathematical physics [Uravneniya matematicheskoĭ fiziki] 2nd ed., Moscow-Leningrad, Gosudarst. Izdat. Tekh.-Teor. Lit., 1950, 424 pp.

This book reproduces an introductory course taught by the author at the Moscow State University. For the most part it deals with the classical equations of potentials, heat conduction, and wave propagation. The theory of integral equations is developed and used, and so is Lebesgue integration. The presentation is rigorous, clear, and vivid. L. Bers, USA

330. Smirnov, M. M., Some nonhomogeneous boundary problems of the equation of heat conduction (in Russian), *Prikl. Mat. Mekh.* **15, 3,** 367–370, May-June 1951.

Two examples of the method of N. P. Erugin [AMR **4,** Rev. 444] are carried out. Both involve the heat equation with nonhomogeneous boundary conditions. R. E. Gaskell, USA

331. Kholmyanskiĭ, M. M., On the solution of systems of algebraic equations in the plane theory of elasticity and of some problems in the technical theory of bending of thin plates (in Russian), *Prikl. Mat. Mekh.* **15, 3,** 317–322, May-June 1951.

Assuming that the circle is conformally represented on a certain region by the polynomial of p-th degree according to the method

of Muskhelishvili, the problem is reduced to finding the solutions from p equations which each contain p complex unknown values. This series of equations may be replaced by following $u = 2p - 2$ or $u = 2p$, which are real equations with u unknowns. Author introduces certain simplifications in the solutions of those equations and considers separately both a case when the plate has no axis of symmetry and when it has $n > 1$ axes of symmetry.

Witold Wierzbicki, Poland

332. **Toupin, R. A., A variational principle for the mesh-type analysis of a mechanical system,** Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-19, 2 pp.

The mesh-type equations for a dynamical system consisting of N-mass points are derived from the Newtonian form of the equations of motion. The appropriate Lagrangian for a variational principle is established for these equations.

From author's summary

333. **Branson, N. G., Metal wall thickness measurement from one side by the ultrasonic method,** *Elec. Engng.* **70**, 7, 619–623, July 1951.

Article discusses the principles of metal-wall-thickness measurement from one side and an instrument for making such measurements. The selection of quartz crystal and range, accuracy, and limitations of the method are covered.

From author's summary

334. **Clarke, E., Carlin, J. R., and Barbour, W. E., Jr., Measuring the thickness of thin coatings with radiation back-scattering,** *Elec. Engng.* **70**, 1, 35–37, Jan. 1951.

The back-scattering of radiation from radioactive substances is being used now to measure thin coatings. This is a nondestructive process which can be used in production wherever measurement is to be made of a coating which has a different atomic number from the backing material. From authors' summary

Mechanics (Dynamics, Statics, Kinematics)

(See also Rev. 332)

335. **Artobolevskiĭ, I. I., Mechanism for raising to third power** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79**, 6, 933–935, Aug. 1951.

If A, one end of a unit leg of a carpenter's square, slides along a fixed straight line b while the other leg of the square always passes through a fixed point B at unit distance from b, the midpoint D of the first leg of the square will trace the cubic curve known as the cissoid of Diocles. Author supplements this well-known mechanism by a rod passing through D and pivoted at the fixed point C, where BC is perpendicular to b, C is on the side of b opposite to B and its distance from b is one-half unit. Let m be the distance from the line BC of the point of intersection of this rod with a scale a which is parallel to b and midway between B and b. Then if n is the distance from A to the line BC, it is shown that $m = n^3$. Therefore, the mechanism can be used for obtaining the cube of a given number or its cube root.

Michael Goldberg, USA

336. **Smart, E. H., Advanced dynamics. I: Dynamics of a particle. II: Dynamics of a solid body,** New York, London; Macmillan & Co., Ltd., 1951, xi + 419 pp., xi + 420 pp. $12.

These two volumes are typical in style of many English texts. They present a fine collection of problems and exercises which not only require a thorough understanding of the basic mechanics to be applied, but also considerable ingenuity, in many cases, in making the applications. One gets the feeling, in looking over the material in the texts, that stating the definitions and principles of the basic mechanics has been considered a necessary evil to prepare the reader for the solution of problems. This defining material is not presented too carefully; e.g., great care is taken to distinguish between speed and velocity when they are defined, but they are used more or less interchangeably thereafter. (This error is almost universal.) Although a directed line segment is given three attributes early in Volume I, namely, length, direction, and sense, later in the volumes the word "direction" is used in its lay sense.

On page 10 there is a discussion of "the velocity of one moving point relative to another moving point" without the introduction of two frames of reference.

On page 41 it is stated that "the moment of a pair of coplanar localized vectors is equal to the moment of the resultant" when it should say "the localized resultant."

It is stated on page 78 that curvilinear motion must be treated in equations of motion in mutually perpendicular directions.

The definition of work—"A force is said to do work when its point of application undergoes displacement"—should have been enlarged by the phrase "in the line of action of the force."

The historical sketches on major contributors and contributions in the field of mechanics which are given at the end of several sections of the volumes contribute materially toward making the books interesting and useful.

The first volume is composed of ten chapters, with the following headings: Introduction; Fundamentals of dynamical principles; Rectilinear motion of a particle; Acceleration parallel to rectangular axes; Radial and transversal accelerations in central forces; Free motion under the laws of inverse square; Constrained motion in two dimensions; Motion in a resisting medium; Motion of a chain in two dimensions; Motion of a particle in three dimensions.

Volume II is made up of thirteen chapters, under the following titles: Moments and products of inertia; Plane kinematics; D'Alembert's principle and the equations of motion; Two-dimensional motion of a rigid body (finite forces); Two-dimensional motion of a rigid body (impulsive forces); Dimensions and dynamical similarity; Motion in three dimensions (two chapters); Lagrange's equations; Motion under no forces; Motion of a top or gyrostat; Hamilton's equations; Theory of small oscillations.

M. G. Scherberg, USA

337. **Trent, H. M., An alternative formulation of the laws of mechanics,** Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-30, 4 pp.

Author proposes a set of laws of mechanics which are duals of those of Newton. These laws are based upon the concept of continuity of transmitted forces around closed loops. They are particularly useful in engineering problems where only knowledge of forces is of interest, since the laws lead directly to equations in which forces are the dependent variables.

From author's summary by A. Schild, USA

338. **Banach, S., translated by Scott, E. J., Mechanics,** Warszawa-Wroclaw, Polskie Towarz. Matematycz., 1951, iv + 546 pp.

This book contains author's lectures on mechanics, given for many years at the Jan Kazimierz University and the Lwów Polytechnic Institute. It is a textbook on the mechanics of particles and rigid bodies, well printed and illustrated with diagrams, covering the traditional field for general university requirements, including those of engineering students. The chapters deal with theory of vectors, kinematics of a point, dynamics of a material point, geometry of masses, systems of material points, statics,

kinematics and dynamics of a rigid body, virtual work, dynamics of holonomic systems, variational principles of mechanics. The English-speaking reader must, of course, accommodate himself to the use of left-handed axes, which is no great hardship; however, this is combined with the rather confusing convention that a right-handed rotation is positive, so that the formula for the velocity of a point of a spinning body is $\mathbf{v} = \mathbf{r} \times \omega$ instead of $\mathbf{v} = \omega \times \mathbf{r}$, as given in English and also French texts, where the left-handed axes are used with the more natural convention that a left-handed rotation is positive. The confusion is increased by a misprint in line 9, p. 46, where the order in the vector product is reversed.

Engineering students develop their understanding of mechanics by working through many special problems; the large amount of text devoted to the solution of such problems should give them the necessary experience, although it might have been well to include some unsolved exercises to test their power. Anyone interested in the logical structure of mechanics turns to the general theory underlying the problems, and, although the arguments are, in general, clearly and explicitly stated, one can hardly accept the statement (p. 73) that if a material point is at rest, then it is said to be in equilibrium. The same statement is repeated (p. 234) with reference to a body. On p. 287 it is stated that if a system of rigid bodies is in equilibrium, the sum and total moment of the external forces are zero; this is followed by the statement that this condition is only sufficient, but not necessary, for equilibrium (sufficient and necessary should be interchanged). The potential V is defined so that force is its gradient. Thus, when potential energy is introduced, it is $-V$, and the kinetic potential is $W = E + V$ and the Hamiltonian $H = E - V$, E being the kinetic energy. This deviation from what is now a fairly well standardized notation seems unnecessary.

But apart from these criticisms, the book contains a complete and careful exposition of mechanics within the bounds set. In the chapter on variational principles, the treatment of variations is more logical than is usual in comparable books. One notational device seems worthy of general adoption: differentiation with respect to the time is indicated by a dot in a superscript position following the differentiated quantity, instead of above it.

J. S. Synge, Ireland

339. Malkin, I. G., On the solution of the problem of instability in the case of two purely imaginary roots (in Russian), *Prik. Mat. Mekh.* **15**, 2, 255–257, Mar.-Apr. 1951.

Author treats the problem of stability of a periodic motion subject to a system of small perturbations.

$$dx/dt = -\lambda y + X(x, y, x_1, \ldots, x_n)$$
$$dy/dt = \lambda x + Y(x, y, x_1, \ldots, x_n)$$
$$dx_s/dt = p_{s1}x_1 + \ldots + p_{sn}x_n + p_s x + q_s y + X_s(x, y, x_j),$$
$$(s = 1, \ldots n)$$

where λ, p_{sj}, p_s, q_s are constants and X, Y, X_s are functions of x, y, x_j, analytic about the origin, whose power series expansions begin with terms not lower than the second degree. When $x_1, x_2, \ldots x_n$ are considered as functions of x, y, the stability of the given equation is the same as that of

$$dx/dt = -\lambda y + X(x, y, v_1, \ldots v_n);\ dy/dt = \lambda x + Y(x, y, v_1, \ldots v_n)$$

where the v's are governed by the equations

$$[\lambda x + Y(x, y, v_j)]dv_s/dy + [-\lambda y + X(x, y, v_j)]dv_s/dx$$
$$= p_{sj}v_j + p_s x + q_s y + X_s(x, y, v_j),\ (s = 1, \ldots n)$$

Author discusses the solution of the last equation in the form of power series. It is shown that through a change of variable from (x, y) to polar coordinates (r, θ), the solution can be obtained straightforwardly.

Y. C. Fung, USA

340. Malkin, I. G., On a method of solution of the problem of stability in the critical case of a pair of purely imaginary roots (in Russian), *Prikl. Math. Mekh.* **15**, 4, 473–484, July-Aug. 1951.

Author takes up the problem of stability of motion in the critical case when the characteristic equation of the first approximation of the perturbed equations of motion has a pair of purely imaginary roots $\pm\lambda i(\lambda > 0)$ and the real parts of all the other roots are negative. This case has been treated previously by Lyapunov ["Problème général de la stabilité du mouvement," *Ann. Math. Studies*, no. 17, Princeton Univ. Press, chap. 2, 1947] and recently by the author [see preceding review].

In present paper a new method is derived. In comparison with the papers mentioned above, the simplicity of the new method is due mostly to the fact that the differential equations of the perturbed motion are not taken in the real canonical form as given by Lyapunov [op. cit.] but in a complex form in which the critical variables are separated, or more generally in the form

$$dx_s/dt = \Sigma_j q_{sj}x_j + X_s \quad (s = 1, 2, \ldots, m) \qquad [*]$$

in which no separation of the critical variables is made. The q_{sj} in [*] are constants such that the equation $|q_{sj} - \delta_{sj}\rho| = 0$ has $m = n + 2$ roots of the types mentioned in the first paragraph. The X_s are analytic in x_j at the origin and begin with terms of degree at least two. A formal solution of equations [*] is obtained in the form

$$x_s = x_s^{(1)}(u, v) + x_s^{(2)}(u, v) + \ldots,$$

where $x_s^{(k)}$ are forms of degree k with respect to the variables u and v, satisfying the equations

$$du/dt = i\lambda u + A_3u^2v + A_5u^3v^2 + \ldots,$$
$$dv/dt = -i\lambda v + \bar{A}_3uv^2 + \bar{A}_5u^2v^3 + \ldots,$$

and A_j and $\bar{A}_j$ are conjugate complex constants. For the solution of the problem of stability it is sufficient to calculate the forms $x_s^{(k)}$ and the constants A_k up to the degree p for which the real part of A_p is different from zero for the first time, say Re $(A_p) = g \neq 0$. Then if $g > 0$, the unperturbed motion is unstable; but if $g < 0$, it is asymptotically stable. In most cases met in practical applications, the real part of A_3 turns out to be different from zero. If the X_s do not contain second-degree terms, author is able to given an explicit expression for the coefficient of stability g.

E. Leimanis, Canada

341. Dyson, F., Principles of mechanism, London, New York, Toronto: Oxford Univ. Press, 1951, vi + 368 pp. \$3.

This text on mechanics and kinematics of machines is organized into following chapters: I and II, plane motion, force, work and energy; III and IV, velocity and acceleration diagrams (the method by instant centers being minimized); V, special geometric and analytical methods for treating displacements, velocities, and accelerations in the slider crank linkage (including the exact expression for slider acceleration); VI, gear tooth forms (omitting reference to items such as tooth interference, angles of action, and contact ratio); VII, fixed-center and planetary gear trains; VIII, friction; IX, belts and ropes; X, turning moment diagrams, flywheels; XI, governors; XII, balancing; and XIII, cams. Coriolis' law is considered in the Appendix.

In reviewer's opinion, the treatment of each subject is satisfactory, except that on gear tooth forms, which is very abbreviated. Due no doubt to the attempt to include both mechanics and kinematics of machines in a reasonable length under one cover, book lacks as coherent a development as might otherwise be expected.

Lloyd R. Koenig, USA

Gyroscopics, Governors, Servos

342. **Chiappulini, R., Contribution to hydraulic duplicating machines** (in German), *Schweiz. Arch.* **17,** 9, 268–275, Sept. 1951.

Simple analysis of hydraulic duplicating machines is given. Only the static performance is considered; dynamic analysis will follow in a later paper. It is shown that a positive displacement system is superior to the open center (pressure-controlled) system. Positive displacement system with cascaded open center valve is also considered. Effect of friction is considered and a system is proposed to minimize such effects. Andrew Vazsonyi, USA

343. **Fel'dbaum, A. A., Investigation of the dynamics of automatic regulation systems by the method of generalized integral criterion** (in Russian), *Elektrichestvo* no. 7, 18–24, July 1951.

Author investigates conditions under which the transient response $x(t)$ of a control system occurs in the neighborhood of an optimum response curve $x^*(t)$ which, as he shows, corresponds to the extremum of a certain integral. He considers the case when the controlled process is expressible by a linear differential equation of the n-th order, which he replaces by an equivalent system of n differential equations of the first order. He introduces the integral $I_v = {}_0\int^\infty V\,dt$, where V is a quadratic form in terms of the solutions of this differential system, and shows that the extremum of this integral yields precisely $x^*(t)$. The recommended procedure reduces to the following steps: (a) Determination of the coefficients of V so as to obtain a curve admissible from the standpoint of the control process; (b) determination of the parameters of the control system so as to render the difference $x(t) - x^*(t)$ as small as possible; and (c) the determination of this difference throughout the range of regulation. An example of this calculation is given at the end. N. Minorsky, France

344. **Hrones, J. A., and Reswick, J. B., Nondimensional study of proportional-plus-reset control of a single-capacity system,** *Trans. Amer. Soc. mech. Engrs.* **73,** 5, 511–516, July 1951.

Article deals with transient response of first-order lag process using proportional-plus-integral controller. System is analyzed using block diagram and operational calculus techniques. Various system parameters are combined into certain nondimensional quantities. A complete set of transient responses, obtained from an analog computer, are presented which might be used to assess the general behavior characteristics of this system.

Reviewer believes the specific case studied is too simple to fully illustrate the techniques presented, and that the idealization masks certain basic effects. For instance, authors show very stable responses for a gain of 40 and large reset rate, whereas almost immeasurably small additional lags would cause the system to be unstable. A. S. Boksenbom, USA

345. **Loeb, J., A general criterion of stability of servomechanisms—seats of hereditary phenomena** (in French), *C. R. Acad. Sci. Paris* **233,** 5, 344–345, July 1951.

A graphical method for the determination of the stability of servomechanisms that contain nonlinear components is presented. Nonlinearities produced by saturation, hysteresis, Coulomb and other types of nonlinear friction are considered. It is pointed out that the complex transfer function of the system is a function of the frequency and of the amplitude when nonlinearities are present. The stability criterion that is presented is pointed out to be a generalization of the Kochenburger criterion and of the Nyquist criterion for linear servo systems. Louis A. Pipes, USA

Vibrations, Balancing

(See also Revs. 354, 376, 434, 453)

346. **Weidenhammer, F., The clamped rod loaded axially by a pulsating force as a stability problem** (in German), *Ing.-Arch.* **19,** 3, 162–191, 1951.

Author considers problem of stability of longitudinal forced vibrations in a uniform homogeneous elastic bar with clamped ends. Type of instability assumed is lateral vibration. Hamilton's principle is used to develop the equations of motion for both longitudinal and lateral motion, damping excluded. Damping is then included by adding a term to the differential equation derived from Hamilton's principle by usual variational methods. Suitable changes of variable are made and the problem is formulated in terms of a new variational principle, damping included. Solutions are found for (1) sinusoidally varying end load, and (2) sinusoidally varying end load superimposed on a static thrust. Two cases are studied: (a) Forcing function frequency very small compared to lowest-mode natural longitudinal frequency; and (b) forcing function frequency not small. Stability of motion is investigated from two points of view, and regions of stability and instability are described. Examples are worked out numerically for (1)(a), (2)(a), (2)(b), and (1) in the neighborhood of longitudinal resonance. Work is complete in mathematical detail and is well presented. Important references are given. H. J. Plass, USA

347. **Belyakova, V. K., Vibrations of a plate under a free surface taking into account small magnitudes of second order** (in Russian), *Prikl. Mat. Mekh.* **15,** 4, 504–510, July–Aug. 1951.

The computation of the waves produced in a liquid by small vibrations of a body under its free surface takes into account, as a rule, only small magnitudes of first order. Paper reviewed gives the shape of waves on the surface considering small magnitudes of second order, also. Special attention is given to the liquid's motion at a long distance from the vibrating body. With her more exact assumptions, author calculates frequency, length, and amplitude of the waves in the cases where usual methods in respect to small magnitudes of first order lead only to paradoxical results.

From mathematical point of view, present paper is rather difficult. Author applies complex variables and some special facts of advanced wave theory. Computation gives complicated and sometimes cumbersome expressions. Some slight misprints make study of the paper difficult. V. Vodicka, Czechoslovakia

348. **Chetaev, D. N., On the impedance of a rectangular plate vibrating in an opening of a flat wall** (in Russian), *Prikl. Mat. Mekh.* **15,** 4, 439–444, July–Aug. 1951.

A vibrating piston in an infinite wall generates aerial waves. The mechanical impedance of the piston, i.e., the force on the piston divided by its velocity, is found by integrating the pressure over the surface of the piston. The pressure itself, found by means of the velocity potential, is also an integral over the surface of the piston. Article gives a reduction of the four-fold integral for the impedance of a rectangular piston to a simple integral involving the integral sine and -cosine functions. W. H. Muller, Holland

349. **Downham, E., The experimental approach to the problems of shaft whirling,** *Aero. Res. Counc. Lond. curr. Pap.* no. 55, 8 pp., 1 fig., June 1950, published 1951.

The theoretical and practical aspects of shaft whirling are discussed and a brief survey is given of past work. A new experi-

mental approach to the problem is suggested and discussed. A detailed program of experiments is outlined. The design of model test rigs is also considered and a description is given of a rig built at the Royal Aircraft Establishment for investigating the theory of shaft whirling. From author's summary

350. Ziegler, H., Stability problems in straight rods and shafts (in German), *Z. angew. Math. Phys.* **7**, 4, 265–289, July 1951.

An analysis is set up for finding the critical rotational speed of shafts subjected to combined torque and thrust for a variety of boundary conditions and in several systems of coordinates. This problem can be treated dynamically by investigating the stability of small oscillations, or quasistatically by methods essentially the same as those used in buckling problems. Author finds that the two treatments lead to different results for some types of end support; for example, in the case of a shaft clamped at one end and free at the other. The discrepancy is attributed to the nonexistence of a torsional potential for such support conditions. For these conditions, previous solutions for simple buckling in the presence of torsion require re-examination.

If any torque is present in the clamped-free case, the dynamic solution apparently leads to instability for all rotational speeds. The discrepancy between this result and common experience is attributed to the facts that the thickness of commonly used shafts makes some of the assumptions in the theory rather approximate, and that the analysis neglects damping. The suggestion is made that an experimental investigation be undertaken to see whether the predicted instability occurs under less usual torque conditions. S. B. Batdorf, USA

351. McLachlan, N. W., Application of Mathieu's equation to stability of nonlinear oscillator, *Math. Gaz.* **35**, 312, 105–107, May 1951.

Author considers the slightly nonlinear equation $\ddot{x} + \epsilon(x^2 - 1)\dot{x} + ax = 0$, where $a > 0, 1 \gg \epsilon > 0$. He states the periodic solution to the second order in ϵ as given by the perturbation method. Substituting a solution that differs from the periodic solution by v into the equation yields a differential equation for v that is transformed into a standard Mathieu equation when the first approximation of the periodic solution is used and only linear terms in v are retained. By reference to usual techniques, the solution is shown to be stable.

Albert I. Bellin, USA

352. Dörr, J., Determination of fundamental torsional frequencies of a certain group of shafts with singularities at their boundaries (in German), *Öst. Ing.-Arch.* **5**, 3, 217–225, 1951.

Author reduces second-order Sturm-Liouville equation for torsional vibrations to disguised form of the hypergeometric equation and thence derives analytical expressions for the fundamental frequencies. Torsional rigidity (kept in constant proportion with inertia moment by assuming cross sections to remain geometrically similar) is distributed according to a law containing two parameters and tends either to zero or to infinity at one boundary at least.

Author states certain distribution shapes suggest applicability to resonant conditions in gyroscopes or centrifuging rotors. Reviewer feels results should be used with caution when the assumption of solid rotation in a cross section, underlying the original equation, tends to be invalidated. According to elasticity theory, this would seem to be the case (1) if cross dimensions vary rapidly; (2) if the actual distribution of inertial body forces has to be considered because of high angular velocities.

B. M. Fraeys de Veubeke, Belgium

Wave Motion, Impact

(See also Revs. 372, 493)

353. Müller, A., On the dependence of the speed of propagation and the damping of a train of waves on their wave length in elastic tubes (in German), *Helv. physiol. Acta* **9**, 2, 162–176, 1951.

In a previous paper [title source, **8**, p. 228, 1950], author has found that the head of a train of waves, propagating itself in a tube with elastic walls (rubber tube), exhibited a larger speed of propagation than the crests and troughs of the waves. A new series of experiments has been made, using two tubes, interior diam approximately 3 cm, wall thickness 0.06 cm and 0.584 cm, respectively. It was found that the phase velocity of the waves increased with the frequency, and the speed of the head and that of the tail of a train of waves again appeared to exceed the phase velocity. This phenomenon is in accordance with the theoretical formula for the group velocity. An attempt made by the reviewer to check this formula from the author's data for the phase velocity was only partially successful, and some discrepancies remained. These may be due perhaps to effects of damping which can cause a difference between the speed of the head of a train of waves and the theoretical group velocity. The damping of the waves appeared to increase strongly with the frequency.

The viscosity of the liquids used had very little influence on speed of propagation and on the damping.

J. M. Burgers, Holland

354. Ghosh, M., and Ghosh, S. K., Dynamics of the vibration of a bar excited by the longitudinal impact of an elastic load, *Indian J. Phys.* **25**, 4, 153–162, Apr. 1951.

Two problems on the longitudinal impact of a bar by an elastic body are treated by the operational method. In the first problem, a body of elasticity E_2 strikes the free end of a bar of elasticity E_1, the other end of the bar being fixed. In the second problem, the elastic body strikes one end with the other end free, so that the displacement of the struck end is determined from the equation of motion of the striking mass. The results are analyzed for relative values of E_2 and E_1, the special case of a rigid mass striking the bar being given by $E_2 = \infty$. The usual discontinuities in the stress at time intervals of $2l/c$ are found for $E_2 = \infty$. For $E_2 \neq 0$ these discontinuities are rounded off. Duration of contact of the striking mass is also found to be a function of E_2.

W. T. Thomson, USA

355. Davies, T. V., The theory of symmetrical gravity waves of finite amplitude. I, *Proc. roy. Soc. Lond.* (*A*), **208**, 1095, 475–486, Sept. 1951.

Determination of irrotational waves of finite amplitude was the subject of classical research by Stokes, Rayleigh, Havelock, and others. Equation of the wave profile was found by successive approximations; difficulty was that convergence of the methods was never proved. Therefore, Levi-Civita's paper is important because it establishes the existence of these waves and the exactness of previous results (even if not specifically proved in this paper). But, with Levi-Civita's boundary conditions, the breaking of waves cannot be investigated because the nonlinear condition at the free surface of the liquid is replaced, as a first approximation, by a linear one, and the general term of the series cannot be easily determined. In present paper, author, using the same functional method, approximates the nonlinear boundary condition by another nonlinear condition which preserves essential features of the original one, and for which the exact analytical solution may be determined, even if not with the most accurate approximation. This approach is suited to present the problem in all its aspects. Method shows some important results for an

infinitely deep channel: Stokes' result that the crest angle at breaking point is 120° is confirmed; the value of the ratio $a/\lambda = 0.1443$ (a wave-amplitude, λ wave length) is obtained and is very near to the value given by Michell; and a formula for the kinetic energy of the fluid per wave length is given.

Giulio Supino, Italy

356. **Longuet-Higgins, M. S., A theory of the origin of microseisms,** *Trans. roy. Soc. Lond.* (*A*), **243,** 857, 1–35, Sept. 1950.

Author considers existing theories of the origin of microseisms (more or less continuous ground motion not connected with earthquakes) with periods of 3–10 seconds to be inadequate. He refers to a result of Miche, that in standing waves in deep water there is a second-order pressure variation which is not attenuated with depth and must ultimately predominate. If groups of ocean waves of the same wave length travel in opposite directions they should produce waves in the ocean bed with twice their frequency. Resonance increases the effect. The displacement of the ground at a distance of 2000 km from the center of a storm covering 1000 km² is estimated to be of the order of $6^1/_2$ microns. In the microseism periods, half of those in the ocean waves should prevail. This has been found in some observed instances. Variation of the frequency response with ocean depth and more rapid damping of higher frequencies may affect the frequency spectrum.

B. Gutenberg, USA

357. **Leggett, D. M. A., A note on the stressing of oleo-pneumatic shock absorbers,** *Aero. Quart.* **3,** part 2, 128–132, Sept. 1951.

Author investigates mathematically the stresses set up in hollow cylinders, representative of shock absorbers in various aircraft tail-wheel units and certain hydraulic jack designs having at least one built-in end and subjected to combined axial loading and internal pressure.

Results show maximum stress, occurring at the built-in end, is usually caused by prevention of circumferential expansion. The induced maximum bending stress is found to be approximately $(3)^{1/2}$ times the corresponding hoop stress, and in practice it is considered to be, on occasion, the cause of fatigue failure because of local yielding of the material.

From author's summary by R. E. Heninger, USA

Elasticity Theory

(See also Revs. 331, 373, 379, 391, 548)

358. **Leibfried, G., On the atomic theory of elasticity** (in German), *Z. Phys.* **129,** 307–316, 1951.

Born was the first to reduce the elastic constants to atomic data by inserting into the atom-theoretical expression for the stresses such displacements of the single atoms which, from the viewpoint of the theory of elasticity, correspond to a homogeneous distortion. From this a relation follows between stress and distortion, i.e., the elastic constants. A second method by Born is based on the theory of propagation of plane waves in a crystal. In past years, doubts, especially about the first method, have been expressed; thus P. S. Epstein [*Phys. Rev.* (2) **70,** 915–922, 1946] questions the correctness of the entire method, especially with regard to the Cauchy relations. Other authors assert that Born's result comes out right only through accident, etc.

Contrary to these assertions, the author proves that Born's calculations are right. To this end he uses a method which was indicated by Born but not carried out. Analogously to the earlier calculations, the existence of a potential energy between each two particles of the lattice is assumed. This energy depends only on the distance, central forces only being considered. The accruing displacements are very small, so that one can develop the theory in powers of them. The transition to the theory of elasticity is then made so that only very slow displacements, variable with the position, are considered and described by a displacement field. The equations of motion of the atoms then follow from the Euler-Lagrange differential equations and, by comparing them with the equations of the phenomenological theory of elasticity, one finally obtains the elastic constants. Discussed first is the primitive translation lattice composed only of one sort of atoms, and then the general case. In the first, the Cauchy relations are valid always; in the second, only under certain assumptions, already discussed by Born.

T. Neugebauer, Hungary

359. **Sherman, D. I., On stresses in a half-plane possessing weight, and weakened by two circular holes** (in Russian), *Prikl. Mat. Mekh.* **15,** 3, 297–316, May-June 1951.

Author's purpose is to study tunnels in mining and hydrotechnics. Assuming that the holes are located at large distances from the boundary of the half plane, the semi-infinite region is replaced by an infinite plane with given tractions at infinity. Two-dimensional stress potentials of Kolosov and Muskhelishvili, in the form of functions of a complex variable, are applied. After long and skillful manipulations, author arrives at an integral equation and replaces it by a system of linear algebraic equations.

Numerical solution is given for the case when the ratio of hole diameters is three and the smallest distance between their boundaries is equal to the radius of the smaller hole.

High level of mathematics and the cumbersome numerical computation required in every special case are, in reviewer's opinion, the obstacles to using this method in engineering.

J. M. Klitchieff, Yugoslavia

360. **Weber, C., Plate in uniform tension with a hole bounded by two arcs** (in German), *Z. angew. Math. Mech.* **31,** 7, 193–201, July 1951.

The radii of the two arcs of circles bounding the hole are equal. The area around the hole is conformally mapped by two inversions and two translations onto a part of a plane bounded by two straight lines enclosing the same angle 2α as the tangents of the arcs at their intersection point. Airy's stress function F satisfying $F = 0$ and $\partial F/\partial\mu = 0$ at the boundaries is found, i.e., at $\mu = \pm\alpha$. [See also AMR **3,** Rev. 846.] The stress function for the wedge is expanded in an infinite series in terms of ρ^n and μ, where ρ and μ are polar coordinates and n is a root of the characteristic equation $(2n\alpha)^{-1} \sin 2n = (2\alpha)^{-1} \sin 2\alpha$. The complex roots of this equation are found graphically. The coefficients of this series are determined by considering the boundary conditions. If a finite number of terms are taken, the boundary conditions can be satisfied at a finite number of points only.

Numerical results are presented for $2\alpha = 3\pi/2$; the error in boundary values is calculated for using the first two terms only in the series expansion.

S. Sved, Australia

361. **Graffi, D., Some questions in hereditary elasticity** (in Italian), *Atti Accad. Naz. Lincei Rend. Cl. Sci. Fis. Mat. Nat.* (8) **10,** 1, 25–30, Jan. 1951.

Author treats particular cases of the Volterra theory of hereditary elasticity, where the tensor of deformation enters as a linear expression in the stress tensor and two additional terms represent the hereditary effect by means of integrals over a certain time period $\tau = 0 \ldots t$; the latter contain corresponding values of the stress tensor component multiplied by two functions $g(t,\tau)$ and $h(t,\tau)$; τ is the variable of integration. In the general three-dimen-

sional case, with external forces given over the boundary of the body, he proves the theorem that the stress tensor (but not the tensor of deformation) is independent of hereditary effects, if either the linear invariant of the stress tensor (in the nonhereditary case) is a linear function of the coordinates only, or if the two functions g and h satisfy the relation $\sigma g(t.\tau) - (1 + \sigma)h(t.\tau) = 0$, where σ is Poisson's ratio. A corresponding theorem will hold for the tensor of deformation in the case when the displacement vector is given across the boundary surface. In the two-dimensional case with given surface forces, the first theorem will hold without additional conditions. Folke K. G. Odqvist, Sweden

362. Robinson, K., Elastic energy of an ellipsoidal inclusion in an infinite solid, *J. appl. Phys.* **22**, 8, 1045–1054, Aug. 1951.

Author gives a solution for the problem of an ellipsoidal inclusion in an infinite solid under uniform change of temperature and for the case in which the infinite medium and the surface of the inclusion are submitted to a homogeneous state of stress whose principal directions are parallel to the axes of the inclusion. The solution of the stress problem is essentially given by M. A. Sadowsky and E. Sternberg [AMR **3**, Rev. 440]. A superposition of two problems solved in the referenced paper gives the solution for the present problem. After selecting five independent Lamé functions suitable for the problem, author also gives a solution for the problem in which the displacements on the surface of the inclusion and at infinity are given. The elastic energies are given for various special cases (elliptic disk, elliptic cylinder, sphere, prolate spheroid) which have been obtained previously in the literature as mentioned in the paper. Dyadic notation is used throughout the paper.

A. Cemal Eringen, USA

363. Föppl, O., The basic equation of the theory of elasticity $\epsilon'_x = \sigma'_x/E - (\sigma'_y + \sigma'_z)/mE$ is applied incorrectly. It is valid only in special cases (in German), Mitt. Wöhler-Inst., Beibl. Heft 44, 7 pp., 1950. DM 1.

The analysis of this paper, as of other recent papers by the same author, is based upon misconceptions, and is characterized by disagreement with certain fundamental postulates accepted universally in the current mathematical theory of elasticity. In this paper, author states that the conventional linear stress-strain relation for isotropic elastic media is valid only in certain cases. This relation, often presented on a purely theoretical basis, is substantiated directly by experimental data for homogeneous stress-strain states. In the mathematical theory of elasticity, it is postulated that the same relation holds for nonhomogeneous stress-strain states. Physical intuition suggests that this is correct, certainly as a first approximation, but otherwise the postulate is substantiated indirectly only by comparison between experimental and theoretical data for nonhomogeneous stress-strain states. The author's criticism of this postulate appears to be based upon purely theoretical grounds, and such criticism is untenable because the postulate involves no internal inconsistency in the fundamental postulates of the mathematical theory.

H. G. Hopkins, USA

364. Suppiger, E. W., Riparbelli, C., and Ward, R., The determination of initial stresses and results of tests on steel plates, *Weld Res. Suppl.* **16**, 2, 91s–104s, Feb. 1951.

Paper deals with the known hole method based on Kirsch's solution. A practical procedure using SR-4 strain gages is described in detail and the gage arrangement giving most accurate results is recommended. Authors conclude that a double radial strain rosette on each side of plate centered at point where stresses are desired gives satisfactory result. Strains are measured before and after drilling the hole at rosette center, and initial stresses are calculated from strain differences using sensitivity coefficients obtained by calibration test. Reviewer calls attention to alternative hole method described by R. Gunnert [*Industritidningen Norden*, Nov. 1951]. Sverker Sjöström, Sweden

365. Vlasov, V. S., Basic differential equations in general theory of elastic shells, *Nat. adv. Comm. Aero. tech. Memo.* 1241, 58 pp., Feb. 1951.

Translation from *Prikl. Mat. Mekh.* **8**, 1944.

Experimental Stress Analysis

(See also Revs. 364, 365, 396)

366. Jessop, H. T., The scattered light method of exploration of stresses in two- and three-dimensional models, *Brit. J. appl. Phys.* **2**, 9, 249–260, Sept. 1951.

Paper deals with an experimental technique of relevant significance in three-dimensional photoelasticity, and which is still in its infancy. As an introductory note, it develops the elementary theory of formation of interference fringes in light scattered from a polarized beam passing through a stressed model.

Interpretation of fringes in terms of tensions is given and two cases are considered: First, secondary principal stresses in the plane of the wave front of the primary beam have constant directions for all points on the path of the beam; second, secondary principal stresses are changing in direction. For this case, using the simplified vibration theory, author obtains the differential equation connecting the observed rate of change of phase difference, with the rate of change in relative retardation due to stress, and the changes in orientation of the axes (Mindlin and Goodman equation). A qualitative estimate of the magnitude of the effect produced by the rotation of the axes is suggested. Some reference to materials and their scattering properties is made.

Author uses a point-by-point method for the analysis of models with scattered light. The optical system is designed for obtaining an intense narrow beam of light at a point of the model. Fringe position is measured by means of a traveling microscope. The microscope can be traversed parallel to the axis of the light beam by a micrometer screw, and is provided with illuminated cross wires. For more accurate readings, a Babinet-Soleil compensator is used, with a modified lens system. Model-holder used is a device with universal motions, which can be turned in any required direction for easy examination of the model. Model is submerged in a liquid of the same refractive index to avoid undesirable reflections and refractions of the light.

Four examples of method are given. The first two are problems of plane stresses. The third example analyzes the second principal stress difference in a plane of symmetry of a three-dimensional model. The fourth is devoted to the exploration of the stress distribution in the fillet of a shouldered shaft under torsion. In this last case, the stress-concentration factor obtained experimentally is more than 20% greater than that quoted by Timoshenko ["Theory of elasticity," p. 283, McGraw-Hill Book Co.] In all examples, "frozen" models are used.

Reference of the degree of precision of the method is given by comparing the experimental results, in the case of a circular disk subjected to concentrated diametral loads, with those of the theory of elasticity; the discrepancy found is less than 3%. Reviewer believes that if this paper contains no essential novelties in the scattering method, the technique the author proposes seems to be useful in many problems, such as those of stress distribution on the surface of a three-dimensional model.

There are few reports of work in this field. The more important accomplishments have been carried out by Weller [*Nat. adv.*

Comm. Aero. tech. Note 737, Nov. 1939; *J. appl. Phys.* **12**, 610–616, 1941]; Drucker and Frocht [*Proc. Soc. exp. Stress Anal.* **5**, no. 2]; Frigon [*Proc. 15th. Semi-Annual Eastern Photoelasticity Conf.*, pp. 68–73, June 1942]. The best results have been obtained in the case of pure torsion. Besides this last problem there are others of greater importance for which the scattering analysis is the best way; e.g., those problems in which the large distortions of the fixation method are not admissible.

The investigations in this field presented by the author are of outstanding importance.

César Augusto Sciammarella, Argentina

367. **Day, E. E., Characteristics of electric strain gages at elevated temperatures,** *Proc. Soc. exp. Stress Anal.* **9**, 1, 141–150, 1951.

Effect of temperature on gage factor is presented for 21 commercial SR-4 gages; maximum temperature approximates 200 F for nitrocellulose-bonded, 450 F for resin-bonded gages. "Advance" and "iso-elastic" wire units were tested in both groups. Under short-time loading (about 30 sec), gage factor is substantially constant up to a critical temperature, at which it starts to fall off rather rapidly. Apparently only one gage of every type was tested; no indication is given whether the wide variations reported in critical temperatures of gages of similar construction are attributed to differences in gage length and geometry, drying conditions, or other causes.

G. Sved, Australia

368. **Frocht, M. M., A photoelastic investigation of stress concentrations due to small fillets and grooves in tension,** *Nat. adv. Comm. Aero. tech. Note* 2442, 45 pp., Aug. 1951.

The stress-concentration patterns are experimentally determined for symmetrically disposed notches and fillets in tension members. Two ratios of gross width to net width are employed, approximately 1.5 and 2. Ratios of groove radius to net width ranged between approximately 0.01 and 0.10; the ratios for fillets were of less extent. The minimum radius employed for both grooves and fillets was $^1/_{32}$ in.

Careful consideration is given the accuracy of results. Methods of analysis and the instrumentation are detailed. Stress-concentration factors are tabulated and comparative plots are given. Principal stress diagrams and isopachic patterns are given for the notched specimen. Photographs of the isochromatic fringe patterns are included.

George H. Lee, USA

369. **McClintock, F. A., On determining principal strains from strain rosettes with arbitrary angles,** *Proc. Soc. exp. Stress Anal.* **9**, 1, 209–210, 1951.

Construction of Mohr's circle in determining principal strains has already been given by Glenn Murphy [*J. appl. Mech.* **12**, 4, A-209, 1945; also his book, "Advanced mechanics of materials"]. From the geometrical analysis of the circle, author deduces the expressions which give the angle and the principal strains in the above-mentioned general case where the angles between the outer gages and the center gages are different.

Arturo M. Guzmán, Argentina

370. **Levy, S., Recent developments in the Ramberg vacuum tube accelerometer,** *Proc. Soc. exp. Stress Anal.* **9**, 1, 151–158, 1951.

Displacement of two cantilever-supported anodes varies plate resistances oppositely in special electron tube, which is thus acceleration-responsive well below natural frequency of plates. Present model features improved stability and drift, obtained principally by decreasing anode-support stiffness to $^1/_5$, and by closer attention to aging and gettering. With natural frequency of 160 cps and 16.7-volt anode supply, average fractional change in plate resistance per g-acceleration unit is about 0.1. Maximum 4-hr drift is 0.04 g, and range is 10 to 20 g.

Vincent Salmon, USA

371. **Vedam, K., Photoelastic properties of barite,** *Proc. Indian Acad. Sci. Sec. A*, **34**, 3, 161–172, Sept. 1951.

All the 12 elasto-optic constants of barite have been determined and the values obtained for λ 5893 are (1) $p_{11} = 0.21$; (2) $p_{22} = 0.24$; (3) $p_{33} = 0.31$; (4) $p_{44} = 0.002$; (5) $p_{55} = -0.012$; (6) $p_{66} = 0.037$; (7) $p_{12} = 0.25$; (8) $p_{13} = 0.16$; (9) $p_{21} = 0.34$; (10) $p_{23} = 0.19$; (11) $p_{31} = 0.275$; (12) $p_{32} = 0.22$.

The behavior of the optical properties of barite on uniform compression on all sides is discussed. The true temperature coefficients of the three principal refractive indexes have also been calculated.

From author's summary

372. **Hudson, D. E., and Terrell, O. D., A pre-loaded spring accelerometer for shock and impact measurements,** *Proc. Soc. exp. Stress Anal.* **9**, 1, 1–10, 1951.

An accelerometer of the pre-loaded spring type is described with which accelerations from 25*G* to 1300*G* can be recorded vs. time. Calibration and typical results are presented. Reviewer considers accelerometer developed an excellent one, but with two limitations that should be noted: First, this accelerometer will give questionable results for falling portions of an acceleration curve; and second, the natural frequency of the spring will affect the time interval of recording accelerations.

Robert J. Hansen, USA

373. **Vasarhelyi, D., Contribution to the calculation of stresses from photoelastic values,** *Proc. Soc. exp. Stress Anal.* **9**, 1, 27–34, 1951.

Author describes the calculation of stresses along any arbitrary section of a photoelastic model based on the Lamé-Maxwell equations. A numerical summation of finite differences is used. The summation is made along a saw-tooth line along the arbitrary section, the saw-tooth being obtained from the stress trajectories. Two methods of obtaining the stress trajectories are mentioned, one derived from photoelastic observations, the other using a brittle lacquer technique. Two different forms are presented for the summation.

An illustrative example determines stresses in a square plate with compressive loads applied to opposite corners. The data are obtained from the same problem in "Photoelasticity," vol. 1, by M. M. Frocht, who solves the problem by the shear-difference method. Author's two solutions are compared with Frocht's. A static check indicates the new methods are not as accurate as the shear-difference method, but this is explained as arising from inaccuracies in obtaining data. Explanation is difficult to follow in places.

William B. Stiles, USA

374. **Kuske, A., Photoelastic methods [Verfahren der Spannungsoptik]**, Düsseldorf, Deut. Ingenieur-Verl., 1951, 134 pp. DM 10.

Book covers a large part of the field of photoelasticity, emphasizing fundamental principles of the methods and reducing mathematical explanations to a minimum. Particularly interesting is the method author develops to integrate graphically the stress equation, using loci of points instead of individual lines. The three-dimensional freezing technique is dealt with in detail, including criteria for test evaluation and the description of instruments developed by author to determine the axis of the principal stresses. One chapter deals with several phases of the photoelastic coating method applied to prototypes and to the study of

the stress distribution in plates. Another chapter explains the fundamentals of the scatter-light method. In reviewer's opinion, book will prove itself useful mainly in industrial laboratories.

A. J. Durelli, USA

375. Kuhn, R., Partial solution by photoelasticity of the problem of bending stresses in plates based on the analogy between plate and disk (in German), *Forsch. Geb. Ing.-Wes. Ausg. B*, **17**, 2, 45–50, 1951.

The differential equation of the deflected surface of a plate and the equation of Airy's stress function for a plane stress state have the same structure. This fact makes possible an analogy between plate bending and two-dimensional stresses. Wieghardt (1908) used the analogy to determine two-dimensional stresses by means of tests with plates. With the aid of photoelasticity, it is easier nowadays to make model tests of two-dimensional stresses. For instance, reviewer has studied temperature stresses in plates by means of photoelastic model tests [*Tekn. Skrifter*, Stockholm, 1944]. Kuhn now gives a method for determining influence curves for the bending moment in a clamped plate with lateral load. The influence function is, according to Pucher, divided into one "singular part K_0" and one "regular part K_1." The solution K_0 is taken from Pucher. K_1 is determined by means of the photo-elastic method. The details in the photoelastic design agree with these of the "München-school" (Föppl-Mönch-Hiltscher).

Kuhn's results seem to be sufficiently accurate. His method seems, therefore, to be of value for evaluating influence curves in plates with lateral load. Reviewer, however, is of the opinion that for methods of supports other than clamped edges the difficulties will be greater.

Henrik Nylander, Sweden

Rods, Beams, Shafts, Springs, Cables, etc.,

(See also Revs. 324, 350, 357, 437)

376. Salion, V. E., Dynamic stability of a plane form of deflection (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **78**, 5, 873–875, June 1951.

For a simple beam of thin rectangular cross section, loaded at the ends with equal, periodically varying bending moments, author derives the condition of resonance and, for the first zone of resonance, shows the dependence of critical moments with respect to the amplitude of primary moment.

Z. Bažant, Czechoslovakia

377. İnan, İ., General expression of moments on the supports in continuous beams with equal bays and uniform moment of inertia (in French), *Bull. tech. Univ. Istanbul* **3**, 1, 67–70, 1950.

In unloaded panels of continuous beams, support moments can be expressed as hyperbolic functions of the ordinal number k of the panel. For loaded parts, the solution contains a further term depending on load intensity. This has been described by Bleich and Melan ["Finite difference equations in structural statics," Berlin, 1927] and others. Present paper points out that, when load intensity of a panel with ordinal number k is written as $a \cos kc + b \sin kc$ (a, b, c parameters), closed solutions for moments can be derived. Examples are given.

H. Craemer, Germany-Egypt

378. Grasshoff, H., A simple approximation method for calculation of elastically supported beams (in German), *Bautechnik* **28**; 7, 8; 160–163, 189–191; July, Aug. 1951.

Unknown deflections y_i are introduced for eight equidistant points of the beam. The local reactions per unit length of the beam are supposed to be $p_i = cy_i$. The modulus of the foundation c is given. The distributed reaction of the foundation is replaced by a system of 16 triangular loads, each of which contains an unknown p_i. By superposition of elementary deflection formulas, six equations can be derived for the p_i. With two additional equations of equilibrium there results a system of eight linear equations for the eight unknowns.

Author points out that in this method (due to Levinton, 1947) one can take into account a variable c by putting $p_i = c_i y_i$. He improves the method by splitting up the load into a symmetrical and an antimetrical part. Two systems, each of four linear equations with four unknowns, are now to be solved. Two numerical examples are given for symmetrical load and variable symmetrical modulus of foundation. The results are in good agreement with calculations of Ohde [*Bauingenieur*, 1942].

W. L. Esmeijer, Holland

379. Ashwell, D. G., The axis of distortion of a twisted elastic prism, *Phil. Mag.* (7) **42**, 331, 820–832, Aug. 1951.

Author discusses the finite distortion of a thin-walled prism under uniform torsion. Analysis based on engineering theory (not on the strict mathematical theory of elasticity) with the assumptions clearly stated enables an axis of distortion to be determined. The position of this axis was found to agree satisfactorily with some experiments.

Roy C. T. Smith, Australia

380. Carrizo Rueda, J. E., Contribution to the cable problem (in Spanish), *Cienc. y Técn.* **114**, 575, 217–235, May 1950.

Author begins by deriving the known parametric equation of a catenary, $z = a \cosh (x/a)$. If the value of a is determined for any particular case, the length of the cable and the stress at any point can be readily computed. A procedure is presented for obtaining the value of the parameter by successive approximations, based on relationships derived for a parabola. The procedure is illustrated by a numerical example involving a cable suspended from towers placed at different elevations. It is, perhaps, worth mentioning that values for cable stress in the illustrative problem differ by less than one-half per cent from those that would be obtained by treating cable as parabola.

James P. Michalos, USA

381. Koval'skiĭ, B. S., Theory of multiple winding of rope (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **74**, 3, 429–432, Sept. 1950.

The axial tension in any turn of rope-winding decreases with its radius r. Therefore, the decrease of length of each r due to the pressure exerted by the turns of greater r produces the decrease of the axial tension in a given turn. Author introduces the notion of a coefficient of transversal compression K and derives the integral equation for the axial tension in the turn of the rope with radius r divided by the breadth of the rope. Author uses the above equation as a basis for introducing diagrams, assuming a priori a certain law of relationship between axial tension and radius, which show that taking into account the transversal deformations of the rope greatly decreases the axial tension in each turn of winding. The transversal deformation of the rope also has great influence on the pressure exerted by the rope on the drum. In this example, the pressure of the rope on the drum, by taking into account the transversal deformations of the rope and of the drum, is 50 kg/cm² and, by neglecting these deformations, is 437 kg/cm².

Witold Wierzbicki, Poland

382. Kappus, R., Shear stresses in curved bars (in French), *Rech. aéro.* no. 21, 49–51, May-June 1951.

Author considers plane problem of curved bars under end loads. Neutral axis does not coincide with line of centroids. Macro-

scopic equations of equilibrium of various elements of the bar yield a simple differential equation for variation of shearing stress over the cross section. As an example, a rectangular cross section is considered, the radius of curvature of the line of centroids being equal to the depth. Maximum shearing stress there exceeds that for straight bar by 13%. G. E. Hay, USA

383. **Langhaar, H. L., Torsion of curved beams of rectangular cross section,** Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-14, 5 pp.

Paper presents an exact solution superseding O. Göhner's approximate solution [*Ing.-Arch.* **2**, p. 619, 1930; no. 1, 1931]. The solution employs a modified Bessel-function stress function. The stresses at a particular section of the rectangular beam are calculated numerically, and the results are compared with those obtained by G. Liesecke [*Z. Ver. dtsch. Ing.* **77**, 425 and 892, 1933] who used Göhner's theory. Liesecke's results indicate close agreement with J. Krahula's results presented in this paper and based on Langhaar's theory. The stress distribution is quite different from that which results by torsion of a straight bar of same cross section. If the effect of pitch is neglected, the above results may be applied to helical rectangular-bar springs.
Dimitri Kececioglu, USA

384. **Buxton, W. J., and Burrows, W. R., Formula for pipe thickness,** *Trans. Amer. Soc. mech. Engrs.* **73**, 5, 575–581, July 1951.

It is shown that the Bailey-Nadai formula for thick-walled cylinders subjected to internal pressure loads at elevated temperatures is practically identical with the so-called Lamé formula based upon the maximum circumferential tensile stress occurring at the inner wall surface in the case of elastic deformations. Therefore, this Lamé formula, in a less complex modified form, is recommended for design purposes as long as additional experimental data on creep and on stress rupture fail to interfere.
J. A. Haringx, Netherlands

385. **Borsoff, V. N., Accinelli, J. B., and Cattaneo, A. G., The effect of oil viscosity on the power-transmitting capacity of spur gears,** *Trans. Amer. Soc. mech. Engrs.* **73**, 5, 687–694, July 1951.

Paper reports tests on aircraft-quality steel spur gears in a four-square machine to determine effect of lubricant properties on onset of scoring failure. Authors state that, at failure loads, thin film lubrication exists, hydrodynamic theory does not apply; they give results to show effect of change of "oiliness" of lubricant. Similarity between factors considered in the Lewis equation for gear-tooth strength and those applying to scoring capacity is noted. A Lewis-type equation including lubricant viscosity is found to agree remarkably with the test results on straight mineral oils. Authors emphasize limitations of results presented. Discussers suggest alternate bases for correlation of data. Further work would be worth while in extending validity of such an equation for selection of gear lubricant.
Daniel K. Wright, Jr., USA

386. **Tuplin, W. A., Gear-tooth stresses at high speed,** *Instn. mech. Engrs. appl. Mech.* (*W.E.P.* no. 59), 162–167, 1950.

Usual gear design for strength includes empirical factors which have been developed at low and moderate speeds. Modern practice includes speeds for which such factors should be re-examined. Paper discusses dynamic stresses induced by tooth-spacing errors in gear teeth operating at high speed; 10,000 rpm and 25,000 fpm pitch-line speed are mentioned. Author calculates approximate stress due to assumed typical pitch errors plus deflection of teeth by transmitted load, and concludes that dynamic increment load at any speed cannot exceed the greater of (a) resultant pitch error times equivalent stiffness of teeth, or (b) [2 × nominal load × (a)]. On this basis, author demonstrates advantage of high-strength steels for high-speed gears, effect of increasing accuracy of tooth spacing on permissible transmitted load, and rejects common practice of using a velocity factor which decreases indefinitely as speed increases. Daniel K. Wright, Jr., USA

387. **Joughin, J. H., Naval gearing—war experience and present development,** *Instn. mech. Engrs. Proc.* **164**, 2, 157–168, 1951.

Vibration, scuffing, and breaking at the roots have been the three main sources of gear trouble. Shortcomings in manufacture and design are discussed. A test program has been established to correct pinion helices for deflection and misalignment. Frequent reference to British naval engagements makes for more interesting reading. Edward G. Fischer, USA

Plates, Disks, Shells, Membranes

(See also Revs. 357, 360, 375, 398, 399, 419, 435, 461, 464)

388. **Hirsch, R. A., The effect of a rigid circular inclusion on the bending of a thick elastic plate,** Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-12, 5 pp.

Problem is solved by using Reissner's theory of bending of plates which takes account of transverse shear deformation and which requires the satisfaction of three boundary conditions at the edge of the rigid circular inclusion. Graphs are given showing how this solution connects the limiting cases of vanishing inclusion size (plane strain), and vanishing thickness (Poisson-Kirchhoff plate theory). Stress concentrations are calculated and plotted versus the inclusion diameter-plate thickness ratio.
A. E. Green, England

389. **Nash, W. A., Several approximate analyses of the bending of a rectangular cantilever plate by uniform normal pressure,** Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-28, 4 pp.

Three methods are presented of approximating the deflections and moments occurring in a rectangular cantilever plate subject to uniform normal pressure over its entire surface. The first uses the well-known finite-difference procedure. The second and third are collocation methods, one based upon polynomial solutions of the Lagrange equation, the other employing "mixed" hyperbolic-trigonometric terms satisfying this equation. In the last two methods the boundary conditions are satisfied exactly along the clamped edge and at a finite number of points along the free edges of the plate. Results obtained for the particular case of a cantilever plate with uniform normal load indicate that the use of a relatively small number of points in the collocation method yields values of deflections and moments that agree substantially with those given by the finite-difference procedure. It cannot be concluded from these results that the collocation method using the assumed functions will give satisfactory results with fewer points than the finite-difference method for cantilever plates with loading different than the one investigated.
From author's summary by D. L. Holl, USA

390. **Uflyand, Ya. S., Bending of sector-plates with a clamped contour** (in Russian), *Prikl. Mat. Mekh.* **15**, 4, 515–518, July-Aug. 1951.

Paper is an enrichment of the theory of thin elastic sector plates with a clamped contour. The solution is assumed as an integral

of Fourier type, whereby an indefinite load is applied along the curved part of the contour. The kernel of the Fourier integral and the load of the plate's curved contour are found according to the boundary conditions.

For the load under consideration the author obtains a very complicated integral equation and he shows, for special cases, what good results can be found by solving it in the most approximate way possible. It is very important that, in contrast to other papers on this subject, the exactness of the results increases with the diminishing of the central angle, as a rule,

Finally, the exactness of the author's solution increases with increasing the sector's radius R, and, for $R \to \infty$, the solution becomes exact. V. Vodicka, Czechoslovakia

391. Korenev, B. G., On deflection of a plate on an elastic foundation, caused by loads distributed along a straight line and a rectangle (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79**, 3, 411–414, July 1951.

In a previous note [AMR 5, Rev. 66] author used a double Fourier series solution for the same problem. In present paper, the step to a Fourier integral is performed and various types of foundation characteristics are considered. The case of the conventional "foundation modulus" is obtained as a particular case in this more general theory. George Herrmann, USA

392. Meissner, E., The elasticity problem for thin shells of toroidal, spherical, or conical shape, *David W. Taylor Mod. Basin Transl.* 238, 15 pp., July 1951.

Translation from *Physik. Z.* **14**, 1913.

393. Torroja, E., and Batanero, J., Cylindrical shells. Introduction to the study of shell structures (in Spanish), *Inst. técn. Constr. del Cem. Publ., Madrid* no. 85, 55 pp., 1950.

First, authors write the usual expressions relating forces and moments per unit length to stresses and principal radii of curvature, and relating stresses to strain. A system of three partial differential equations for the general case of laterally loaded cylindrical shells is then obtained. For application to practical problems, Finsterwalder's approximate theory of bending of cylindrical shells is introduced. This involves the assumption that the twisting moments and the moment and shear in the axial planes can be neglected. Finally, using Finsterwalder's method, a numerical example is presented based on a reinforced-concrete shell roof designed and built in Spain.

James P. Michalos, USA

394. Hodge, P. G., Jr., and Prager, W., Limit design of reinforcements of cut-outs in slabs, *Grad. Div. appl. Math. Brown Univ. tech. Rep.* no. 2, 17 pp., Aug. 1951.

Paper is concerned with the problem of thin square slab with central circular cut-out subjected to uniformly distributed tensile stress on the four edges. The flow limit is determined, i.e., that value of the tensile stress for which unrestricted plastic flow sets in. Reinforcing rings are welded to the two sides of the slab and then designed so that the reinforced slab has the same flow limit as a unreinforced slab without cut-out.

The analysis is an application of the general method, developed by Drucker, Greenberg, and Prager ["Extended limit design theorems for continuous media," to appear in the *Quart. appl. Math.*], to states of plane stress in a perfectly plastic material which obeys Tresca's yield criterion of constant maximum shearing stress. Two basic theorems used in the analysis are: (1) The flow limit is the largest load intensity for which it is possible to find a statically admissible stress field; (2) the flow limit is the smallest load intensity for which it is possible to find a kinematically admissible velocity field. T. H. H. Pian, USA

395. Morris, R. M., The boundary-value problems of plane stress, *Quart. J. Mech. appl. Math.* **4**, part 2, 248–256, June 1951.

Previously, author(s) have discussed the plane stress problem for an infinite aeolotropic plate containing an elliptic hole. The complex variable method was used. Here, finite elliptic aeolotropic plates are considered. The branch points, which formerly were outside the plate region, now lie inside the region considered and care is necessary to insure single-valued potential functions.

Three problems are treated in detail: (a) Edge loading stresses are constant; (b) trigonometric variation in edge stresses, $\widehat{\eta\eta} - i\widehat{\eta\xi} = p_1 e^{i\xi} + p_{-1} e^{-i\xi}$; and (c) resultant applied forces are zero but give rise to a resultant couple. In addition, a more general example of type (b) is considered which, in turn, can be used to give solutions for very general edge-loading conditions. Details of stress distribution are not included. F. S. Shaw, USA

Buckling Problems

(See also Revs. 350, 440)

396. Jackson, K. B., and Hall, A. H., Experimental diagrams of deformation and strain distribution in curved plates under compression, *Nat. Res. Counc. Canad. aero. Rep.* AR-9, 149 pp., 1951.

Report contains 142 figures of experimental data supplementing AR-1 published by the same authors in 1947 [see AMR 1, Rev. 1113]. Buckle contours and strain distributions for loads below and above the buckling load are given for 20 out of the 155 curved and 24 flat aluminum-alloy plates with clamped edges which had been tested in end compression. Nearly all the data were obtained from 1500 photographs of parallel wires and their shadows on the buckled plate. Authors claim to have perfected this technique to the point of determining the deflection of the plate to the nearest thousandth of an inch. Buckle contours illustrate clearly and beautifully the development of the first buckle pattern and the transition into other patterns with more buckles as the load is increased. Walter Ramberg, USA

397. Finzi, L., On the calculation of critical loads by the principle of virtual work (in Italian), *G. Gen. civ.* **89**, 1, 25–36, Jan. 1951.

The principle of virtual work can be applied in two different forms for the calculation of critical loads. In the normal form, which leads to the same results as the energy method by S. Timoshenko, the state of deformation and the state of virtual loading are similar. Author treats a second form in which an arbitrary state of virtual loading, independent of the actual loading, is introduced. A comparison of numerical calculations leads reviewer to the conclusion that this special form of the principle of virtual work is more complicated in application, and gives less exact results, than the normal form. F. Stüssi, Switzerland

398. Plass, H. J., Jr., Sinusoidal torsional buckling of bars of angle section under bending loads, as a problem in plate theory, *J. appl. Mech.* **18**, 3, 285–292, Sept. 1951.

Timoshenko used plate theory to solve the problem of torsion-buckling of an angle bar under thrust. Author makes a similar calculation, assuming the same boundary conditions as Timoshenko but a different load. A linear distribution of stress over the section is assumed so that the resultant is a pure bending moment. A preliminary calculation is made using the Rayleigh-Ritz method to obtain approximate solutions. Author chooses as the form of plate-deflection the product of a sinusoidal function of the coordinate in the direction of the bar and of series functions of the other coordinate in the plate. It is assumed that this

gives a good approximation to the true deflection. In computing approximate values, only one adjustable parameter is used. In this way, the approximate critical load is obtained by a curve as a function of the ratio of width and length of the plate. For a given value of this ratio, several values above and below this value of the approximate critical load of this curve are taken and, for these values, the determinant, which vanishes for the exact solution, is computed. The exact solution follows then by interpolation. A principal difficulty of this method is that the coefficients in the series are complicated algebraic expressions in the ratios of plate. The results are compared with those of bar theory. Difference between the two theories become more noticeable as the bar becomes short, compared to its flange width. The plate theory always predicts a larger value for the critical load than bar theory. The reason for this difference is that in the bar theory the strain energy contributed by bending of the flanges in a plane perpendicular to their middle surface is neglected. This term becomes important when the bar becomes short.

Ludwig Föppl, Germany

399. **Lubinski, A., Buckling of rotary drilling strings,** *World Oil* **132,** 4, 5, 6, 7; 105–114, 137–144, 122–132, 124–130; Mar., Apr., May, June 1951.

The buckling equation of drilling pipes is obtained and integrated by series, assuming the pipe to be a simply supported beam under distributed load. Deflections, bending moments, and inclination at the drilling end are evaluated. The force exerted by the wall of the hole on the pipe is determined. The influence of hydrostatic pressure and of pump pressure is considered. This is an interesting example of applied mechanics in practical engineering.

M. G. Salvadori, USA

Joints and Joining Methods

(See also Rev. 410)

400. **Wesstrom, D. B., and Bergh, S. E., Effect of internal pressure on stresses and strains in bolted-flanged connections,** *Trans. Amer. Soc. mech. Engrs.* **73,** 5, 553–562, July 1951.

Bolted-flanged joints of "nonrigid" type only are discussed; i.e., joints in which outer edges of flanges can be further compressed longitudinally, thereby increasing flange stress as bolts are tightened. Authors base their work on ASME Unfired Pressure Vessel Code, and explain reasons for departing fron this code when designing bolted joint connections. For certain critical ranges of joint diameter, pressure and stress, importance of analyzing design for actual conditions obtained during assembly at test pressure and in service is stressed, and formulas for calculating these conditions are given. Results are outlined as design procedure, and recognition of correct stress analysis of flanges through an understanding of gasket characteristics is brought out. Stresses and elastic characteristics of cover plate are dealt with in appendixes.

This paper should be read in conjunction with those by I. Roberts [AMR, **4,** Rev. 1537] and W. Moheit [AMR, **4,** Rev. 2003], which deal with similar discussions.

S. K. Ghaswala, India

401. **Potter, J. H., and Eitel, W. W., Thermal bolt stress study in a high-pressure flanged pipe joint,** *J. Amer. Soc. nav. Engrs.* **63,** 3, 541–553, Aug. 1951.

Paper reports results of careful measurement of temperature differential between bolts and flange of a high-pressure high-temperature bolted flanged joint for the transient conditions during warm-up. It is pointed out that if this temperature differential is large, high bolt stress increase might occur.

Temperature differential between bolts and flange is given for various conditions of flow and temperature. This differential is smaller than that given by Borsig in another paper.

An equation is given by which bolt stress increase during warm-up may be approximated. Results show that for rapid warm-up with gas stream in line at 1233 F, stress increase in carbon-steel bolts is less than 8000 psi.

Authors conclude that bolt-flange temperature differential and stress increase build up steadily to an equilibrium value and do not pass through any transient values in excess of that of equilibrium. Tests indicate bolt stress increase to be even smaller when joint is insulated.

W. J. Carter, USA

402. **Emerson, R. W., and Morrow, M., Welding high-temperature austenitic steel piping,** *Weld. Res. Suppl.* **16,** 1, 15s–33s, Jan. 1951.

403. **Blaser, R. U., Eberle, F., and Tucker, J. T., Jr., Welds between dissimilar alloys in full-size steam piping,** *Proc. Amer. Soc. Test. Mat.* **50,** 789–808, 1950.

Factors affecting the safe operation of ferritic-austenitic weld joints in large-size steam piping were studied by means of a simulated proof test. The specimen consisted of a $10^3/_4$-in. diam section of $2^1/_4$ Cr-1 Mo steam piping welded to suitably designed and dimensioned end pieces of 18 Cr-8 Ni Cb wrought and 16 Cr-13 Ni-2 Mo Cb cast materials, using 19 Cr-9 Ni Cb welding electrodes. Cracks were detected by radiographic means in the $2^1/_4$ Cr-1 Mo pipe at the edge of the weld joint after 4631 hr at 1100 F and 1500 psi pressure, involving 47 week-end shutdowns to atmospheric conditions.

Metallurgical examination showed that the principal factors contributing to the failure were stresses up to yield strength due to differences in thermal expansion of the ferritic and austenitic materials, accelerated creep, intergranular stress-oxidation and weakening of the ferritic metal adjacent to the fusion zone due to carbon migration into the austenitic weld metal.

From authors' summary

404. **Grezel, J., Carpenters handbook, No. 9: The assemblies** (in French), *Ann. Inst. tech. Bât. Trav. publics* no. 159, 46 pp., Nov. 1950.

Consideration is given to available French information on the design of (1) traditional wood joints, such as scarf joints for compression and tension, mortise and tenon joints, joggle joints, halved joints, notched joints, key joints, and wooden pinned joints; and (2) so-called modern wood joints, such as connections by bolts, nails, dowels, spikes, bolt and bearing plate, and by glue.

Examples illustrate the design procedures involved for the wooden joints.

E. George Stern, USA

405. **Andersen, A., and Granum, H., Investigations on Alligator, Bulldog, Rox, and "Stjerne" timber connectors** (in Norwegian), *Norges tekn.-Naturvitensk. Forskningsrad, Byggetekn. Utvalg, Rep.* no. 2, 1951.

In this report, covering the period from 1945 to 1950, detailed test data are presented on the load-carrying capacity of the described connectors in timbers of various sizes and loaded at given angles to grain.

E. George Stern, USA

406. **Meissner, H. P., and Baldauf, G. H., Strength behavior of adhesive bonds,** *Trans. Amer. Soc. mech. Engrs.* **73, 5,** 697–702, July 1951.

Paper attempts to prove by experimental tests which of five existing theories for the "thickness-strength" rule is correct. Test

data are obtained for butt-jointed cylinders. The diameter of the cylinders and the thickness of the adhesives are varied. Comparison of results with qualitative conclusions of each theory indicates that the "distribution of internal stress" theory is substantiated. In a discussion of the paper, D. M. Alstadt states tests made independently on flat bar stock agree well with the results presented in this paper. Vincent P. Zimnoch, USA

Structures

(See also Revs. 397, 550)

407. Braun, P., Contribution to the moment-compensation method (in German), *Bauingenieur* **26, 7, 207–210,** July 1951.

Analysis of statically indeterminate systems composed of rods and beams by method of moment compensation. This method leads to a system of linear algebraic equations containing as unknowns the "unbalanced moments" at the joints and certain moment quantities related to joint displacements. Numerical example of simple portal frame is given. Some remarks are made on the Cross method and method of joint rotations.

F. J. Plantema, Holland

408. Neal, B. G., The behavior of framed structures under repeated loading, *Quart. J. Mech. appl. Math.* **4,** part 1, 78–84, Mar. 1951.

Framed structures are considered subjected to several loads varying independently between prescribed maximum and minimum values. Shakedown is said to occur if a state of residual stress is reached which enables all further variations of the loads to be supported without additional plastic flow. The theorem is proved that if any system of residual moments can be found permitting this, then the structure will shake down, though not necessarily with this particular residual moment distribution. An ideal moment-curvature relation is assumed for each member involving linear elasticity until the limit moment is reached at which unrestricted bending can occur. E. H. Lee, USA

409. Hailer, J., On the calculation of the deflection of the longerons of steel-framework bridges (in German), *Planen u. Bauen* **5, 17,** 399–401, Sept. 1951.

The calculation of the deflection at the mid-point of two types of pin-jointed beams with parallel chords is developed by classical methods. Using the simplification of substituting a parabola for the real influence line, the other ordinates are obtained. Two numerical examples are included.

Arturo J. Bignoli, Argentina

410. Topractsoglou, A. A., Beedle, L. S., and Johnston, B. G., Connections for welded continuous portal frames, *Weld. Res. Suppl.* 16, 7, 359s–384s, July 1951.

Part I of an investigation of different types of welded joints in rigid frames of the portal type. Problem deals almost exclusively with corner connections used commercially in welded rigid frame structures. Detailed objectives include the general behavior of welded joints under load, elastic stress distribution and strength, rigidity of joints in elastic and plastic range, in the range of the maximum-load ultimate strength and load-deformation characteristics, economics of fabrication.

Method used is experimental and Table I summarizes the results of fifteen separate tests. Fourteen of the joints formed by welding two 8B13 beams together at right angles varying the joint type in each case, were tested in standard testing machines. In all cases, lengths of arms were equal, giving 45° loading. Connection P formed by joining an 8WF31 to a 14WF30 required a special rig involving a hydraulic jack to apply the load. Lateral support, not required in the elastic range, was furnished to provide torsional rigidity in the plastic range. Dial, mirror, Huggenberger, A-11, SR-4 gages were used as required. All tests were carried through to collapse without interruption.

Important results of experiments are as follows: determination of connection strengths and characteristics particularly in the plastic range, strength and stiffness properties of joints, yielding and method of failure, relative costs of fabrication.

Reviewer believes these tests will eventually furnish valuable material for design procedure. Majority of previous tests deal with flexible and semi-rigid connections, and where continuous connections have been tested it has been mostly in the elastic range. These tests should furnish data to predict frame behavior in the plastic range, thus furthering the application of "limit" design methods. An appendix deals with some elementary analytical aspects of plastic design. This is followed by a brief discussion of the paper by H. H. Bleich in which he comments on the high shear stresses in type P connection and the need for proper reinforcement.

For Parts II see the following review. Part III will appear in a later issue and will include the discussion of tests results, conclusions, and acknowledgments. Final evaluation of these experiments will rest to some extent on the material presented in Parts II and III, in reviewer's opinion.

F. L. Castleman, USA

411. Beedle, L. S., Topratsoglou, A. A., and Johnston, B. G., Connections for welded continuous portal frames. II. Theoretical analysis of straight knees, *Weld. Res. Suppl.* 16, 8, 397s–405s, Aug. 1951.

Paper is one of a series dealing with tests of welded portal frames of structural steel conducted at Lehigh University. In order to compare with test results on knee frames, as reported previously in Part I of this progress report [see preceding review], formulas have been derived for stresses and deflections of knees without haunches. Formulas are derived for knees with similar and dissimilar legs. The corner intersection region is considered with and without a diagonal stiffener. The analysis is extended into the plastic range of stress. Simple but reasonable stress distributions are assumed in the corner region as required. The shearing deformation of the corner web is shown to be important. The need for a corner stiffener to develop the full bending strength of the legs is shown in agreement with the test results of Part I. Stanley U. Benscoter, USA

412. Hoff, N. J., Structural problems of future aircraft, 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951. London, Roy. aero. Soc., 77–117,

Author states that advances made during past decade in structural design and analysis are insignificant compared to development of companion fields of propulsion and aerodynamics. Purpose of this paper is to explore current state of the art in structural design and to stimulate interest in anticipated problems.

The inadequacy of thin-walled monocoque construction in current design problems has led to the use of sandwich construction, heavy skins reinforced by closely spaced stiffeners, integrally stiffened panels, and multicell wing arrangements with thick tapered skins. Highly sweptback and delta planforms have introduced problems in analysis because the wing structure behaves as a plate rather than as a beam.

Whereas only selected elevated-temperature problems confront the stress analyst at the present time, in the near future elevated-temperature problems will arise in all phases of stress analysis. These problems require concerted research by metallurgical, ap-

plied mechanics, and aircraft research groups. Detailed analysis is given of an idealized skin-spar configuration under conditions of aerodynamic heating, from which temperature and thermal stress distributions are computed throughout the structure as functions of time. The effects of time at temperature on strength of an element such as a column is indicated by an analysis of the behavior of a linear viscoelastic column containing an initial imperfection.

The most important conclusion drawn from the survey is the necessity of rationalizing our concept of what constitutes a safe structure. To account for the time-dependent behavior of the structure at elevated temperatures our concept of safety will depend upon whether the aircraft is expendable (missile), nonexpendable (basis of design of today's aircraft), or semi-expendable. Under conditions of creep, it probably will not be possible or judicious to design aircraft of the non-expendable category. Thus, the life of the aircraft must be based on new criteria of safety which consider its semiexpendability.

George Gerard, USA

413. **Milwitzky, B., and Lindquist, D. C., Evaluation of the reduced-mass method of representing wing-lift effects in free-fall drop tests of landing gears,** *Nat. adv. Comm. Aero. tech. Note* 2400, 43 pp., July 1951.

Tests are reported for one small undercarriage with the intent of comparing (a) the realistic condition of landing in presence of lift, (b) the so-called reduced mass method—same total energy, no lift, smaller mass, and (c) free-drop tests, as often done.

Comparison of the fundamental parameters is given for the three cases. It can be observed (1) that the real condition of landing in presence of lift does not imply any special difficulty, so that the advantage of using conventional arrangements different from the real one is not clear; (2) that evidently this branch of airplane structures offers opportunity for research.

. The problem, and therefore the paper, has considerable practical importance but no theoretical value.

C. Riparbelli, USA

⊛414. **Gebauer, F., Plasticity theory in reinforced concrete structures [Die Plastizitätstheorie im Stahlbetonbau. Entwicklungsgeschichte und praktische Anwendung mit zahlreichen Beispielen],** Wien, Verlag Georg Fromme & Co., 1949, viii + 184 pp., 92 figs, 15 tables. **DM 18.**

Book is a well-developed plea against the "classical" or "*n*" method of reinforced-concrete design, and for the new method of design based on the plastic behavior of the material. After introductory chapters where the properties of the materials used are reviewed critically, author explains his reasons for believing that the classical method is contradictory. In several chapters the theory of plasticity is applied to columns with and without buckling danger, beams, plates, and torsion cases. Report of many test results and several examples of design are included in each chapter. There are more than 100 bibliographic references.

A. J. Durelli, USA

415. **Kaufman, S., Stability problems in prestressed concrete** (in Polish), *Inżyn. Budown.* **7,** 228–236, 1950.

Expressions are derived for the critical prestressing force by the Ritz-Timoshenko energy method for the general case of cable contacting concrete in many points as well as for continuous contact. Constant and variable cable eccentricity is taken into account. For the single asymmetrically situated contact, the critical prestressing force is reached when one (of the two) parts of the deformed axis remains straight. Thus, one of Magnel's four experiments (the "bizarre" one) is explained theoretically.

W. Olszak, Poland

416. **Op Ten Noort, L. H., Prestressed concrete tanks** (in Dutch), *Ingenieur* **63,** 36, Bt. 65-Bt. 70, Sept. 1951.

Author describes design and calculation of 375,000-gal circular prestressed-concrete sludge digestion tanks, part of the sewage-treatment works at Beverwijk.

Use of high-strength wire makes possible important economies in steel and concrete, whereas the water-tightness of the tanks and the permanent protection of the reinforcement against corrosion are fully provided. Details of the construction procedure are given.

From author's summary

417. **Guzmán, A. M., and Luisoni, C. J., On the calculation of grids of beams** (in Spanish), *Cienc. y Técn.* **117,** 590, 47–65, Aug. 1951.

Authors, who have used Galerkin's variational method extensively in elasticity problems, apply it now to the resolution of grids composed of a large number of beams, considering them as anisotropic plates, and compare the results with those obtained by Navier's method. It can easily be concluded that the amount of work necessary for the resolution in the new way is much less, and the approximation excellent. It is reviewer's opinion, and should be proved by experience, that even for a relatively reduced number of beams, the variational solution proposed by the authors could be more convenient than the resolution of the grid as an indeterminate structure (especially if it is simply supported at the edges), because this latter method gives a set of equations very inconvenient for the resolution. The opposite happens in using the new method of the authors.

Arturo J. Bignoli, Argentina

418. **Eimer, C., Compressed elements in prestressed concrete** (in Polish), *Inżyn. Budown.* **8,** 6, 240–249, June 1951.

Author is concerned with the problem of buckling of prestressed elements when the stretched cable has separate points of contact with the element occurring at regular intervals. Moreover, such a prestressed element is compressed by an external load acting longitudinally and axially. Formulas are worked out for critical values for external compressive and for prestressing loads in various end conditions.

W. Olszak, Poland

419. **Reinitzhuber, F., On the elastostatics of spiral stairs** (in German), *Federhofer-Girkmann-Festschrift,* Franz Deuticke, Wien, 321–347, 1950.

Purpose of paper is to present a method of calculation for metallic spiral stairs considered as a thin-walled prismatic structure. Treads and risers are considered as horizontal and vertical wall-like beams, tied together by shear-resisting connections, and clamped in the stringers which form another system of wall-like helicoidal girders. The system is highly statically indeterminate, but by neglecting some of the deformations it is reduced, for each step, to a doubly statically indeterminate system. The method is developed for uniform loads, and a numerical example shows its application.

Aurel A. Beleş, Rumania

420. **Campus, F., Tests on prestressed concrete** (in Spanish), *Inst. tecn. Constr. Cem.* no. 102, 42 pp., Nov. 1950.

Author describes and analyzes a series of tests conducted in Belgium with different types of structural members of prestressed reinforced concrete.

Especially interesting are static tests with cylindrical beams and tubes, and dynamic tests with railway ties. Among the outstanding conclusions reached are: (a) Validity of classical formulas of proportionality between deformations and forces which originate them, especially in case of bonded wires, whereas the independent deformations of concrete and rods may perturb this

proportionality when rods are unbonded; (b) concept of security in prestressed concrete differs notably from that for other materials, owing to high resistance of steels employed and the fact that their elastic limit is very close to limit of rupture. Security against rupture is normally more than 50% higher than that corresponding to cracking; (c) prestressed spirals are especially effective for tubular cylindrical members, not only from point of view of resistance to internal pressure, but also to diametrical compression; (d) in case of railway ties, a rapid succession of repeated loads produces slipping of wires if they are anchored by bond, and rupture if they are anchored in their ends and not bonded.

Eckhardt Rathgeb, Argentina

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 394, 414, 428, 432, 435, 447, 448)

421. **Fukada, E., On the relation between creep and vibrational loss of polymethylmethacrylate,** *J. phys. Soc. Japan* **6**, 4, 254–256, July-Aug. 1951.

Using a creep-time relation of the semi-logarithm type, author tries to correlate dispersion of Young's modulus and vibrational loss with frequency for polymethylmethacrylate, using Gross's method. He claims that experimental results of the variation of the complex elastic modulus with the frequency are in good agreement with calculated values which are based on some empirical constants. Therefore, to be able to state that amplitude of strain does affect vibrational loss, author concludes that vibrational loss of polymethylmethacrylate in audiofrequency range is caused by the same mechanism as that of static creep, which shows linear deformation with logarithm of time. This conclusion should be subjected to reconsideration. It is shown experimentally that the loss factor depends on amplitude of strain and there is a transitional change from high amplitudes to low ones. Explanation given is that creep relation in low stress range follows exponential type law instead of semi-logarithm law. Reviewer thinks this conflicts with the assumption made, which imposes a serious limitation on statements of author.

Author points out that creep constants in the creep-time relation used in the correlation differ considerably from those obtained by other investigators. To reviewer this seems to put in question the applicability of these constants to the correlation. However, formulation of the creep-time relation, which is the basis of this investigation, does deserve further thought.

Ling-Wen Hu, USA

422. **Chevenard, P., New self-recording dilatometer for physico-thermic analysis of materials, and the measure of their dilatability, with equipment for the study of isothermic hardening** (in French), *Rev. Métall.* **47**, 11, 805–816, Nov. 1950.

423. **Fenske, M. R., Klaus, E. E., and Dannenbrink, R. W., Viscosity-shear behaviour of two non-Newtonian polymer-blended oils,** Symp. Meth. Meas. Viscosity high Rates Shear, *Amer. Soc. Test. Mat. spec. tech. Publ.* 111, 3–23, 1951.

Such oils, ordinary Newtonian up to a definite rate of shear, show (1) non-Newtonian flow behavior in streamline flow above such rate, and (2) permanent loss in viscosity by intense and prolonged turbulent shearing. For (1), oils were forced through calibrated metal capillaries 10 cm in length and 0.034 or 0.025 cm in diam at rates of shear up to 1,000,000 $\sec^{-1}$ with Reynolds numbers up to 1800. For (2), hydraulic pumps equipped with pressure-loading devices were used as specified in Army-Navy Spec. AN-0-366. No permanent viscosity decrease could be observed within streamlined region. The apparatus used for (1) involves a piston pump in which turbulence produces a certain amount of permanent viscosity decrease. This was taken into account by a correction. The molecular weight of the polymers seems to be the principal item influencing the maximum rate of shear below which the oil will remain simple Newtonian. Permanent and temporary viscosity decreases were up to 40%.

M. Reiner, Israel

424. **Calnan, E. A., and Clews, C. J. B., The development of deformation textures in metals. II. Body-centered cubic metals,** *Phil. Mag.* (7), **42**, 329, 616–635, June 1951.

425. **Mott, N. F., The mechanical properties of metals,** *Proc. phys. Soc. Lond.* (*B*) **64**, part 9, 381B, 729–741, Sept. 1951.

Description is given of edge and screw dislocations in a close-packed cubic lattice, which gives an account for the Frank-Read theory of origin of slip bands. By considering a grain containing Frank-Read sources, it is shown that cross slip and formation of deformation bands are to be expected. Formation of vacancies by moving dislocations plays an essential role in these processes. Some speculations on stability of deformation bands are given. It is suggested that movement of vacancies (self-diffusion) plays an essential part in polygonization, recovery, and steady-state creep, enabling dislocations in deformation bands to move out of their slip planes and so relieve stress. It is probable that, in these bands, stresses are several hundred times greater than applied stress. This enables diffusion to occur at temperatures at which it would not be possible otherwise. Account is given of low-temperature creep of type which does not involve recovery.

From author's summary by Albert Kochendörfer, Germany

426. **Nabarro, F. R. N., The law of constant resolved shear stress in crystal plasticity,** *Phil. Mag.* (7) **42**, 325, 213–214, Feb. 1951.

The formula of Peach and Koehler for the total force acting on a dislocation in a stressed crystal is derived by the use of a theorem due to Colonnetti. The same method distinguishes conservative motions of the dislocations, which do not alter the volume, from other motions. The component of the total force which produces conservative motions acts in the glide plane, and is proportional to the same component of the total stress as appears in the law of resolved shear stress discovered experimentally by Schmid.

From author's summary

Failure, Mechanics of Solid State

427. **Bartenev, G., Phenomenon of brittle fracture in silicate glass** (in Russian), *Zh. tekh. Fiz.* **21**, 5, 579–588, May 1951.

Author assumes the following: (1) Time from loading to breaking of glass depends on growth rate of most dangerous flaw in specimen before loading; (2) rate is proportional to stress σ_1 at edge of flaw; (3) relative increase of σ_1 implies equation $d\sigma_1/\sigma_1 = \gamma(d\sigma/\sigma)$ (σ is medium stress in cross section containing flaw, and γ is a constant quantity depending on material and temperature). Author derives relation between breaking time τ and strength P. From that follows, for long times, $lg\tau = a - \gamma lgP$.

Validity of given formulas is investigated in bending tests on specimens of silicate glass (71% SiO_2). Breaking time is measured by method of A. Holland and W. Turner [*J. Soc. Glass Techn.* **24**, p. 46, 1940]. On a series of 100 equal specimens each, breaking time of greatest probability is determined for different loads. Results of author and those of F. Preston [*J. appl. Phys.* **13**, p. 623, 1942] show, in range of 10^5 to about 10 sec, expected linearity

between $lg\tau$ and lgP. For short times, $lg\tau - lgP$-curve deviates from a straight line in the direction of greater strength. Value of coefficient of static fatigue γ depends essentially on chemical composition of glass. According to tests of author, $\gamma = 27$ and to those of Preston, $\gamma = 18$. Heinrich Mussman, Germany

428. **Sokolov, L. D., Systematic investigation of the dependence on speed and temperature of resistance to deformation of single phase metals** (in Russian), *Doklady Akad. Nauk SSSR* (N.S.) **70**, 5, 839–841, Feb. 1950.

429. **Schardin, H., Kinematographic solution of the fracture phenomenon** (in German), *Z. angew. Math. Mech.* **31**, 8/9, 261–263, Aug./Sept. 1951.

This study of brittle fracture propagation in Plexiglas uses high speed camera (100,000 pictures/sec). Photographs are given of pictures taken by tangential illumination and by use of photoelastic technique. In front of fracture, a wave of high stresses moves. When the fracture reaches the border, intensive elastic waves move from the point in both pieces and in the air. Velocity of fracture, 560 m/sec; of elastic longitudinal wave, 2800 m/sec; of elastic transversal wave, 1280 m/sec; of air wave, 340 m/sec.

W. Soete, Belgium

430. **Roš, M., and Eichinger, A., Failure of solid bodies under repeated loading [Die Bruchgefahr fester Körprer bei wiederholter Beanspruchung-Ermüdung]** (in German) *Eidgenöss. MatPrufAnst. Ber.* **173**, viii +.161 pp., Sept. 1950.

This authoritative discussion of the fatigue characteristics of materials is based on a wide variety of observations by the authors and other investigators. Application of theories of failure to repeated loading is discussed with the general conclusion that the Coulomb-Mohr hypothesis is usable in practical situations. The relationship between endurance limit in tension and tension-compression is explored. Effect of geometrical discontinuities is shown to be not as serious under repeated loading as under static loading.

Residual stress effects are discussed, and lack of effects of stress gradient is noted. Limits of applicability of results from small specimens to large specimens are stated. Effect of wear and surface deterioration is important. Creep is treated as a special case of repeated loading. Properties at elevated temperatures are discussed, and necessity of matching test conditions to service conditions is emphasized. Effect of repeated loading upon riveted and welded joints is considered. Viewpoint that factor of safety must be assessed on basis of an estimate of degree of damage is emphasized.

The report is well organized and thoroughly documented. Line drawings and photographs are well selected, and an abundance of experimental data on steels and light alloys is included.

Glenn Murphy, USA

431. **Logan, H. L., Effect of chromium plating on the endurance limit of steels used in aircraft,** *Proc. Amer. Soc. Test. Mat.* **50**, 699–713, 1950.

Chromium plating reduced the endurance limits of both normalized and hardened SAE × 4130 steels, the loss of strength being greater for hardened steels. The endurance limit decreased with increase of both temperature and thickness of the deposit. Baking after plating at 350 C reduced the endurance limit still further, while baking at 440 C gave an improvement of strength. Neither hydrogen embrittlement nor surface cracks on the plating are considered to be the prime cause of the reduction in strength. The damaging effect is attributed to stresses in the chromium or steel which are relieved by baking at 440 C.

J. A. Pope, England

Design Factors, Meaning of Material Tests

432. **Drucker, D. C., Greenberg, H. J., and Prager, W., The safety factor of an elastic-plastic body in plane strain,** Ann. Meeting Amer. Soc. mech. Engrs. Atlantic City, 1951. Paper no. 51—A-3, 8 pp. = *J. appl. Mech.* **18**, 4, 371–378, Dec. 1951.

Extremum principles are applied to find the upper and lower limits of safety factor of an elastic-plastic body of a Prandtl-Reuss material under given surface tractions. The body is in plane strain and is assumed incompressible. The case with surface of discontinuity of tangential velocity in plastic flow is discussed. An illustrative example is shown.

T. H. Lin, USA

Material Test Techniques

(See also Revs. 396, 423, 429)

433. **Földes, G., New testing machine for plastics** (in German), *Schweiz. Arch.* **17**, 7, 209–214, July 1951.

A new tension and compression testing machine for plastics is described. The machine is of small size and can be mounted on a small table. The load is applied hydraulically with special controls giving uniform rates of head motion for a given valve setting irrespective of load. A double-acting piston provides both tension and compression loads to the specimen. The load is measured by a mechanical system that is completely independent of the loading system. The load is transmitted through a lever with three alternative fulcrum positions to one of four calibrated springs, the deformation of the spring being indicated on a scale graduated to read load. Tension load ranges of 10, 50, 100, 500, and 1000 kg and compression load ranges of 100, 500, 1000, and 1500 kg are provided. The machine is provided with a maximum pointer, replaceable graduated scales for each range, and a set of grips for testing round and flat specimens. Special jigs are provided for transverse tests and for a determination of modulus. Accuracy of 0.5% from 20% of each scale range to capacity is claimed.

Douglas R. Tate, USA

434. **Horio, M., and Onogi, S., Forced vibration of reed as a method of determining viscoelasticity,** *J. appl. Phys.* **22**, 7, 977–981, July 1951.

"The motion of a clamp-free reed excited by a sinusoidal displacement of the clamped end was analyzed by rigorously solving the fundamental equation for vibration. The real and imaginary (damping) parts of the modulus are given in terms of resonant frequency and band width of the frequency curves. The results are compared with those of Noble [*J. appl. Phys.* **19**, 753–774, 1948] which were obtained in an approximate manner by introducing an equivalent electric circuit. As long as the mechanical loss tangent is smaller than 0.1, the practical error caused by the approximation is estimated to be insignificant."

From the engineering standpoint the results indicate the vibrating reed technique is a simple method of determining the elastic modulus and damping of plastics and similar materials.

From authors' summary by L. E. Nielsen, USA

435. **Hagg, A. C., Cametti, B., and Sankey, G. O., A high-speed, high-temperature precision testing machine for gas turbine disk research,** *Proc. Soc. exp. Stress Anal.* **8**, 2, 17–28, 1951.

A detailed discussion is presented of the equipment, calibra-

tion, test procedures, and performance. The testing machine was designed for experimental studies of plastic flow and creep in rotating disk specimens at elevated temperatures. Primary emphasis was placed on means for accurate measurement and control of test conditions and on the determination of plastic and creep strains occurring under the test condition.

The equipment is capable of testing disk specimens as large as 14 in. in diam and 2 in. thick. Specimens can be subjected to speeds as high as 35,000 rpm and temperatures up to 1500 F. Specimens may be subjected to either uniform temperatures or to gradient conditions. The results obtained show that the average speed error for a run was less than 0.01%, and the maximum instantaneous error was about 0.5%. The specimen temperature errors were shown to be less than 10 F by test calibration. In general, operation of the testing machine was very reliable. Some of the initial test results in disks are presented and indicate that data of high quality were obtained.

P. I. Wilterdink, USA

436. Phillips, C. E., and Fenner, A. J., Analysis of Rockwell hardness test, *Engineering* **172,** 4459, 57–61, July 1951.

Direct-reading hardness-testing machines are now widely employed in industry because of the simplicity and rapidity of testing operation. The introduction of Rockwell hardness tolerances has drawn attention to considerable discrepancies which can arise between results obtained from different testing machines. The investigation now described was undertaken in an attempt to assess the reasons of such differences and to provide a reliable basis for the standardization of hardness blocks. For this purpose, a new testing machine was constructed in which both the minor and major loads are made up of dead weights. The measurements of the vertical movement of the cone are made by means of an optical comparator. The new testing machine differs radically from that of the ordinary commercial types of direct-reading hardness machines. Initially, it was intended for the purpose of standardizing hardness blocks. During the course of the experiments it was found that, in tests of a given block, differences up to about two units could arise between readings using the same cone in different machines, and similar differences occurred between readings obtained with different cones in the same machine, though all the tests were ostensibly made in accordance with B.S. 891/1940. The most likely causes of the discrepancies noted are: (1) Differences in the shapes of cones, and (2) differences in the magnitude of the minor load or the major load, or both.

Twelve high-grade conical penetrators were obtained from current production and their profile shapes were determined in the three axial planes. Eight of the penetrators failed to satisfy the specified conditions. The included angles of six penetrators lay outside the tolerance limits. It is probable that many of the diamond cones produced and employed in industry do not conform to the tolerance limits of radius and angle laid down in B.S. 891. Variations up to 2 or 3 units may arise between cones conforming to the B.S. specification tolerance on radius. Variations in major load have a noticeable influence on the test results. Further investigation of the time influence is desirable.

L. Föppl, Germany

Mechanical Properties of Specific Materials

(See also Revs. 325, 402, 421, 428, 429, 430, 431, 433, 436)

437. Rahlfs, P., and Masing, G., Investigation of the Bauschinger effect in torsion of wires (in German), *Z. Metallk.* 42, 12, 454–459, Dec. 1950.

Authors report torsion tests on wires (0.8–1.0 mm) of carbonyl iron, soft iron, hard copper, brass, tin-bronze, aluminum, aluminum-manganese alloy, aluminum-magnesium alloy. Tests consisted in initial twisting well into the plastic range, followed by reversed twisting through the elastic and into the plastic range. Divergencies between the load-deformation relation during reversal and that predicted from the initial loading relation were partly due to strain-hardening, partly to the Bauschinger effect. Iron, brass, and tin-bronze showed a relatively strong Bauschinger effect, while copper, aluminum and aluminum alloys showed a relatively weak effect.

M. P. White, USA

438. Harris, W. J., Jr., and Rinebolt, J. A., and Raring, R., Upper and lower transitions in Charpy test, *Weld. Res. Suppl.* **16,** 9, 417s–422s, Sept. 1951.

Two transition temperatures are reported for several low-carbon steels. Lower transition is associated with a change in energy for crack initiation. Increasing fracture energy above lower transition is associated with a changing energy for crack propagation. Temperature of lower transition can be fixed by strain markings that are present above and absent below transition.

Reviewer believes lower transition is the result of yielding of uniform section of Charpy bar as described in *J. appl. Mech.* **11,** 1, A28–A34, Mar. 1944; that it represents a weakness in Charpy specimen design, and does not measure a material property.

J. C. Fisher, USA

439. Meincke, H., Determination of tension strength from hardness of aluminum alloys (in German), *Z. Metallk.* **42,** 6, 175–181, June 1951.

Tests are reported in which a correlation between the hardness and tensile strength of aluminum and aluminum alloys is found. Using spherical and knife-edge indentors on rolled, drawn, and pressed materials, in the absence of protective coatings, a conversion factor of $c = 0.364$ is found in converting the average spherical indentation hardness to tensile strength. A maximum deviation of 7.2% exists in this conversion when the relation $P = 5d^2$ exists between the load in kg and the diameter of the indentor in mm.

When comparing the hardness with yield stress, deviations up to 35% occur in calculating the correlation, and the author feels there is no relationship between the two quantities. In this connection, the reader is referred to the work of D. Tabor [see AMR **4,** Rev. 3577].

Louis F. Coffin, Jr., USA

440. Heimerl, G. J., and Barrett, P. F., A structural-efficiency evaluation of titanium at normal and elevated temperatures, *Nat. adv. Comm. Aero. tech. Note* 2269, 16 pp., Jan. 1951.

A structural-efficiency evaluation of titanium including comparisons with several other materials is given for compressive loading without buckling, for column buckling, and for the buckling of long plates in compression or shear. The methods of evaluation, based upon the use of stress-strain curves and structural indexes, are fully described. The comparisons indicate that high-strength aluminum and magnesium alloys are generally more efficient on a unit-weight basis at normal temperatures than commercially pure titanium sheet having a compressive yield stress of about 106 ksi. For short-time loading conditions at temperatures beginning somewhat above 400 F, titanium sheet is more efficient than aluminum alloys.

From authors' summary

441. Eastwood, L. W., Hodge, W., and Lorig, C. H., Aluminum-6 per cent magnesium alloys for elevated-temperature service, *Proc. Amer. Soc. Test. Mat.* **50,** 1013–1033, 1950.

As a result of a systematic study of aluminum-base alloys con-

taining magnesium, the following casting alloy has been developed for elevated-temperature service: magnesium 6%; zirconium 0.05–0.25%; manganese 1%; titanium 0.08%; copper 1.5%; beryllium 0.005%; vanadium 0.1%; aluminum (99.5%) balance. The use of nickel and other alloys is discussed in detail, and the above composition is suggested as the best. Ultimate strength of 35,000 psi is obtainable after heat treatment, and 30,500 psi after stabilizing 18 days at 650 F.

This alloy is not appreciably affected adversely by stabilization at temperatures up to 700 F; it has low density, good resistance to corrosion, good machining characteristics, and, even after stabilization at 600 F, has very high tensile properties. As compared with 142 or Y alloy castings, it has appreciably lower thermal conductivity and somewhat lower resistance to creep at 600 F. Although the above composition has considerably better resistance to creep than previously known aluminum-6%-magnesium casting alloys, still further improvements in creep resistance may be possible.

Pouring techniques, heat treatment, strength temperature effects, and test data are given in considerable detail, including some comparison with other alloys. Ammon S. Andes, USA

442. **Quinn, F. A., Jr., Roberts, D. E., and Work, R. N., Volume-temperature relationship for the room temperature transition in Teflon,** *J. appl. Phys.* **22,** 8, 1085–1086, Aug. 1951.

Specific volume-temperature curves are given for Teflon (polytetrafluoroethylene) over the temperature range −35 C to 130 C. Near room temperature a double transition is observed. About 85% of the volume change is centered around 20 C while the remainder of the volume change, due to the second transition, is found around 30 C. The volume change due to these transitions is 1.23%. The 20 C transition shows a hysteresis effect in that the heating and cooling curves are not the same. The area of the hysteresis loop decreases as the rate of heating and cooling decreases till a steady-state condition is reached.

It is important for engineers to consider the dimensional changes resulting from these transitions when designing Teflon parts requiring close tolerances. Lawrence Nielsen, USA

443. **Foster, G. A. R., Fibre motion in roller drafting,** *J. Text. Inst. Trans.* **42,** 9, T335–T374, Sept. 1951.

Three theories of drafting derived from experience of worsted drawing were recently published. This very interesting paper concerns the roller-drawing process of cotton, where irregular motion of the so-called "floating fibers" is the cause of the drafting wave that—as author showed in a previous paper—is present in all the cotton slivers.

Instead of making assumptions about fiber contacts and forces, author makes assumptions about the motion of the fibers. In part I, a special equation of continuity is derived from the assumptions (a) that all the fibers—being straight, of the same length smaller than the roller setting, and parallel to the axes of the sliver—continue to move at the speed of the back rollers, until their mid-points reach a certain boundary between the rollers, on crossing which the speed of all of them changes to that of the front rollers; (b) that the boundary is not stationary. Admitting that the position of the boundary depends on the number of fibers held by the front rollers, it is found that the system of drafting fibers may be stable or unstable. According to author's experiments, the stable system does not agree with observation and it is suggested that the drafting of cotton normally corresponds to an unstable system, where the drafting proceeds as a succession of breaks in the individual strands of the sliver.

In part II the subsequent fiber motion after one break is calculated for two hypotheses: Hypothesis A is based on the assumption that the distance of the moving boundary from the front boundary is proportional to the total length of fiber, held by the front rollers and projecting into the drafting zone. The calculated wave length agrees well with those observed for two cottons (Punjab and Tanguis), but does not agree with a finer cotton (Uppers).

Hypothesis B (an extension of A) is then made, admitting that the position of the moving boundary depends also on those fast moving fibers which are close to the front rollers. The calculated wave length agrees with those obtained experimentally for the fine cotton (Uppers) and also with those for rovings of the Punjab when twisted higher than normal.

In part III, two other hypotheses C and D, at first sight more plausible than A and B, are examined. They do not lead to oscillations which correspond to the drafting wave. In a general discussion, author gives a rough idea of how the three other theories of drafting which, according to the author, appeared during the final stage of his work, are related to the theory of this paper.

In part IV, the properties of the fiber system are considered more systematically and the investigation is extended.

The paragraphs containing the mathematical developments are in smaller type and may be omitted in a first reading.

D. DeMeulemeester, Belgium

444. **Futagami, T., Breaking strength of glass,** *Memo. Fac. Engng. Kyushu Univ.* **12,** 3/4, 245–261, 1951.

The bending strength (single point loading), tensile strength, modulus of elasticity, and modulus of rigidity (for rods only) are determined experimentally for glass rods and plates, and data are presented in the form of curves and empirical equations. The object was the determination of the size effect for each of these properties. Author finds: (1) Bending strength and tensile strength both show size effect, strengths increasing with decrease in cross-section size. (2) Modulus of elasticity is constant for plates, but displays size effect for rods, decreasing with decreasing cross-section size. (3) Modulus of rigidity for rods decreases with decreasing cross-section size. (4) Poisson's ratio, computed from the modulus of elasticity and modulus of rigidity, decreases with cross-section size. Above results are found also when specimens have been previously notched or cracked. However, reviewer can see no indication that stress concentration at the notch was included in consideration.

From the author's summary: "Conclusions drawn from these results are as follows: (1) A crack is not more than a notch of zero width. (2) The breaking strength is closely connected with the migration of the aggregation units, and the cause of the higher strength of smaller test pieces is ascribed to it. (3) The dimension of an aggregation unit is estimated to be of the order of 1000 Å." Derald A. Stuart, USA

445. **McAdam, G. D., Some relations of powder characteristics to the elastic modulus and shrinkage of sintered ferrous compacts,** *J. Iron Steel Inst. Lond.* **168,** part 4, 346–358, Aug. 1951.

In a large series of experiments with various iron powders, measurements are given for mean particle size and shape, apparent density, pressing density, sintered density, and for Young's modulus of elasticity for various pressing conditions, but for a uniform sintering process.

The elasticity ratio E_n/E for sintered bodies and compact forged iron is determined by the porosity ϵ. For some sintered steels, an empirical formula was found: $E_n/E = (1 - \epsilon)^{3.4}$. The ratio will not be influenced by the size of particles.

An empirical equation is derived from which it should be possible to predetermine the linear contraction of a standard iron-copper-carbon alloy at 1100 C in terms of the packing, pressing and

theoretical densities, and the particle size. The agreement between formula and observations is quite rough.

By combining these relations, the elasticity may be deduced from the shape and compression characteristics of powder particles.
Franz Wever, Germany

446. Rance, H. F., The rheological behaviour of paper, "Some rec. develop. Rheol.," London, United Trade Press, 90–104, July 1950.

Discussion on properties of paper covering anistropy mechanical testing includes a description of a machine built for testing paper over a range of strain rates, and a consideration of the mechanism of yielding. Of particular interest are author's discussions on (1) dropping the load after some deformation, and (2) discontinuing the deformation for a period and then reversing it slightly before continuing the loading. Also of interest are his observations of plastic strain lines in paper analogous to Lüders' or Hartmann lines occurring in stretching of metals. Author concludes with the suggestion that paper is the ideal material for experimenting in rheological research.
F. E. Reed, USA

Mechanics of Forming and Cutting

(See also Rev. 443)

447. Bastien, P., and Winter, C., Criterion of suitability for stamping of steel as obtained from tensile tests and from data of the Kaiser Wilhelm Institute (in French), *Rev. Métall.* **48,** 9, 641–657, Sept. 1951.

Discussion of dispersion of results from tensile tests is given. Dependence of results on cold work and thickness of specimen is shown. Elongation is not a sufficient criterion for stamping suitability. Authors propose introducing modulus μ = ratio of deformation before necking down to corresponding true stress. This index appears significant for sheet steels between 1 and 3 mm thick. Above 3-mm thickness the shape of stress-strain curves gives suitable criterion. For specimens less than 1 mm thick, best criterion appears to be modulus as determined by Kaiser Wilhelm Institute tests in which 40-mm diam pointed punch is pushed through 12-mm hole in mounted specimen.
E. Creutz, USA

448. Lee, E. H., and Shaffer, B. W., The theory of plasticity applied to a problem of machining, Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-5, 9 pp. = *J. appl. Mech.* **18,** 4, 405–413, Dec. 1951.

See AMR **3,** Rev. 2358.

Hydraulics; Cavitation; Transport

(See also Rev. 423)

449. Babbitt J. D., A unified picture of diffusion, *Canad. J. Phys.* **29,** 5, 427–436, Sept. 1951.

It is shown that if the equation $\partial p/\partial \bar{x} - A_x = 0$, where p is a pressure function and A_x a resistive or frictional force, is taken as the fundamental dynamical equation, it is possible to explain diffusion in solutions, in solid solutions, and in an adsorbing solid as well as the interdiffusion of two gases. In diffusion in both liquid and solid solutions the pressure function is the osmotic pressure; in diffusion of absorbed gases the pressure function is the spreading pressure of the adsorbed layer. Since these pressure functions are thermodynamic properties of the system, the pressure gradient is independent of the physical picture assumed for the system. To evaluate A_x, however, it is necessary to assume a specific physical mechanism for the movement of the molecules.
From author's summary by L. J. Tison, Belgium

450. Frank, J., Considerations on discharge at breaks of dams (in German), *Schweiz. Bauztg.* **69,** 29, 401–406, July 1951.

Based on Saint-Venant's formula for celerity of surge, neglecting friction and local losses of energy, and with various simplifying assumptions concerning form of reservoir and breach in dam, author deduces formulas for discharge, head, and depth at dam section. Results are compared with those of Ritter, Schoklitsch and Egiazaroff, but author calls for more experiments. Finally, author calculates discharge from Eder reservoir after break of dam.
H. Thygesen Kristensen, Sweden

451. Crump, S. F., Critical pressures for the inception of cavitation in a large-scale Numachi nozzle as influenced by the air content of the water, *David W. Taylor Mod. Basin Rep.* 770, 18 pp., July 1951.

A 12-scale model of a Numachi nozzle 22, a Venturi-type nozzle with an abrupt diffuser, was tested to determine the critical pressures for the inception of cavitation as a function of the air content of the water. The test results are compared with those of Numachi. Although the absolute values of the critical pressures for cavitation inception do not agree in the two investigations, the same general trends were observed. It is believed that the observed differences are due to vortex formation in the diffuser and Reynolds-number effects.
From author's summary

452. Gaden, D., and Borel, L., Apropos of surge tanks. Effect of the law of variation of the output on the stability condition of Thoma (in French), *Bull. tech. Suisse Rom.* **77,** 9, 117–126, May 1951.

The so-called "formula of Thoma" gives the minimum surge-tank area for oscillations in the tank to be stable when the governor maintains constant output. The relative value of the power variation Δp is then zero ($\Delta p = 0$). The formula of Thoma can be expressed in relative values ($2\,p_0h_0 > 1$, where p_0 is relative head loss in the pressure tunnel, h_0 is relative head, when the unit of length and height is the standard surge for total closing with no head losses in the pressure tunnel). Author shows that better stability for small oscillations can be obtained when connecting the governor to the tank so that $\Delta p = k_h\Delta h_e$ (Δh_e is relative value of small level variation in the surge tank). The surge-tank formula for stability then becomes $2p_oh_o > 1 - k_h$. Alternatively, the governor can be connected to the speed ring so that $\Delta p = k_y\Delta y$ (Δy is relative value of small speed ring displacement). Both methods are for small oscillations only. Large oscillations may be damped by a restricted orifice surge tank. Diagrams summarizing numerical results are given. [See: M. Cuénod, title source, Aug. 12, 1950; G. Evangelisti, AMR **4,** Rev. 1215.]
Charles Jaeger, England

453. Jurecka, W., Stability of oscillations in two surge tanks in series (in German), *Öst. Ing.-Arch.* **5,** 3, 267–278, 1951.

Author derives general fourth-order differential equation for oscillations in two surge tanks in series. He deduces that, for the general case of small oscillations and the particular case of sudden valve-opening and large oscillations, equation reduces to linear homogeneous form and is easily solved. Stability of oscillations is investigated and criteria developed for damping to occur. These correspond to Thoma conditions for single forebay. Example is given to illustrate use of method in proving stability of a system involving two surge tanks and pumped storage. Reviewer believes that paper is of value only where small oscillations occur, because term involving rate of change of level in surge tank

is neglected. Clear presentation of differential equation and solution will be of great use. W. D. Baines, Canada

454. **Casado, F. L., Massie, D. S., and Whytlaw-Gray, R., The densities and limiting densities of vapours,** *Proc. roy. Soc. Lond.* (*A*), **207**, 1091, 483–495, July 1951.

Accurate values of vapor densities are needed for commercial engineering design calculations and are necessary for establishing reliable thermodynamic property values; also they may be used to study association in the vapor phase. A general method has been developed of balancing pressures at the same density of oxygen and vapor. Accurate data were obtained for benzene at 22 C in the region from 19 to 69 mm of benzene pressure.

W. L. Sibbitt, USA

455. **Binnie, A. M., The effect of friction on surges in long pipe lines,** *Quart. J. Mech. appl. Math.* **4**, part 3, 330–343, Sept. 1951.

Method is given for calculating pressure-time history following the closing, either suddenly or at a constant rate, of a valve located at the outlet of a horizontal pipe of constant diameter supplied from a large reservoir. Assumptions are that velocity of pressure wave is constant; reflections at open and closed ends of the pipe are perfect; motion is one-dimensional; particle velocities are small; and wall friction depends on the velocity in the same manner as in steady-state laminar flow. By increasing the friction factor to give the correct head loss at the pipe exit, the method is extended to turbulent flow. After deriving the equation governing the motion, it is solved by use of operational calculus. Although, in general, the method cannot predict the motion up to the time it disappears, it is usually valid at least to the first surge, the surge with the greatest pressure rise. Pressure-time history is calculated for two values of a single nondimensional parameter that governs the motion and that depends on the dimensions of the pipe line and on the properties of the fluid in it. Results of calculations are compared with those of a graphical method. Neal Tetervin, USA

456. **Tison, L. J., Currents in the outlets of lakes and reservoirs** (in French), *Bull. Centre Étud. Constr. génie civ. Hyd. Fluviale* **5**, 387–396, 1951.

Direction of currents approaching the outlet is explained by curvature of the streamlines and difference in pressure. Outflow of a layer with desired quality (temperature, density, salt, or silt content) can be modified by turning the entrance orifice up or down. Some examples are: inundation dams, outlet from lake, and temperature distribution in lakes of Sweden.

Steponas Kolupaila, USA

457. **Baines, W. D., and Peterson, E. G., An investigation of flow through screens,** *Trans. Amer. Soc. mech. Engrs.* **73**, 5, 467–477, July 1951.

Paper presents combined analytical and experimental studies to determine the effect of screen geometry upon pressure drop, modification of velocity distribution, and characteristics of induced turbulence. Screen patterns of coarse lattices and perforated plates were investigated and equations presented for calculating the effect of these screens. All investigations were conducted in a nonrecirculating air tunnel. The air velocity through the test section of the tunnel was adjustable from 1 to 25 fps.

The screens studied were five biplane lattices made of square 1-in. bars with square meshes $1^1/_2$, 2, $2^2/_3$, 4, and 8 in. in size. Two other lattices were made of $^1/_3$ and 3-in. bars, and $1^1/_3$ and 12-in. meshes, respectively. One single plane lattice was made of 1-in. bars with 2-in. mesh. Three perforated plates were made of $^3/_{16}$ in. thick hard board with holes in hexagonal pattern 2, 4, and 8 in. on center, respectively; the corresponding hole diameters were 1.04, 3.14, and 7.40 in. The screen Reynolds numbers were in the range of 10^3 to 10^4.

Experimental results are presented in graphic form throughout the paper and are readily usable for design purposes. Theoretical and experimental data show good agreement for pressure drop. Velocity distribution data show satisfactory agreement for solidity ratios (the fractional degree to which screen obstructs flow) of less than 0.5, whereas solidity ratios greater than 0.5 yield unstable downstream flow with poor agreement. Experimental information is presented which indicates that a distance of 5–10 mesh lengths is required downstream of screen in order to obtain good flow establishment, providing that screen Reynolds number exceeds 100.

Reviewer believes this paper is an excellent start toward experimental verification of the theoretical equations for coarse grids in confined streams of fluid media.

Charles Newman, USA

458. **Gherardelli, L., On the equation of steady flow in prismatic beds** (in Italian), *Energia elett.* **28**, 4, 185–189, Apr. 1951.

The equation of the flow in open prismatic canals has been integrated by Bresse in the case of rectangular canals (1860). Many other solutions were submitted later on for other canal shapes. Author's method appeals because of its simplicity and generality. The equation

$$ds/dh = (1 - q_0^2b/gA^3)(1 - q_0^2/c^2RA^2i) \quad [1]$$

(where q_0 is the discharge, s the abscissa, i the constant slope of the canal, h the water depth and A the area, b the canal width, R the hydraulic radius, and c the friction coefficient of Chezy) can be written:

$$ds/dh = g(h)(h - k)/(h - h_0)$$

where k is the critical depth and h_0 the water depth for uniform flow. Author shows that $g(h)$ is a function depending only on q_0, i, and c and on the geometrical dimensions of the canal, $g(h)$ being nearly linear over a wide variation of h. He, therefore, writes: $g(h) = a + bh$. If $\Delta = h_0 - k$, the integral of [1] between h_1 and h_2 will be:

$$i(s_2 - s_1) = (a + b\Delta)(h_2 - h_1) + b/2(h_2^2 - h_1^2) + \Delta(a + bh_2)\ln[(h_2 - h_0)/(h_1 - h_0)]$$

which is easy to calculate. Examples are given.

Charles Jaeger, England

Incompressible Flow: Laminar; Viscous

(See also Revs. 347, 485, 485, 558, 560)

459. **Truesdell, C., Generalization and unification of vortex laws for plane and rotationally symmetric fluid flows** (in German), *Z. angew. Math. Mech.* **31**, 3, 65–71, Mar. 1951.

Author gives a good historical review of kinematic and dynamic laws of vortex motion. This review leads to a procedure which is nicely presented in the form of four questions that concern the different laws of the behavior of perfect and nonperfect gases. The questions are answered by the mathematical development of a single, new, and purely kinematical conservation scalar-vector theorem which includes the known vortex laws as special cases. The new theorem indicates a double extension of the known laws: (1) an extension of the motion, and (2) an extension of the physi-

cal fluidity which can be considered with a scalar vortex-conservation law. John DeYoung, USA

460. Heinrich, G., On the theory of steady, frictionless vortex flow (in German), *Anz. Akad. Wiss. Wien* **87,** 76–84, **1950.**

461. Hayes, W. D., Effective mass of a deformable circular cylinder, *Grad. Div. appl. Math. Brown Univ. tech. Rep.* no. 1, 5 pp., Aug. 1951.

A long circular cylinder is considered being deformed so that the circular cross section is nowhere altered but the lateral motion is not uniform but sinusoidal. The impulsive pressure on the cylinder is calculated, and by dividing through the local velocity of the body, the effective mass factor can be found. This factor as a function of the wave length of the lateral motion is plotted on a graph. These considerations provide a justification for the method of taking a local effective mass for a long slender deformable body of revolution equal to that of the local displaced volume of fluid times a reduction factor to take care of the effect of the nonuniformity of the velocity distribution or the bluntness of the ends. H. G. Loos, Holland

462. Strscheletzky, M., Incompressible potential flow through straight infinite blade cascades (in German), *Z. angew. Math. Mech.* **31,** 8/9, 282–284, Aug./Sept. 1951.

Using the singularity method, the direct and indirect cascade problem is solved by the substitution

$$\gamma(\varphi) \sin \varphi = \Sigma_{k=0}^{n} R_k \cos k\varphi$$

where $\gamma(\varphi)$ is the circulation function of the blade and $\cos \varphi = -s$; s is the coordinate along the chord which has the length 2. Using the boundary condition in n points of the blade contour and the Kutta condition at the trailing edge, the direct problem is reduced to $(n + 1)$ equations in the $(n + 1)$ unknown coefficients R_k. H. G. Loos, Holland

463. Bellin, A. I., Messina, D. R., and Richards, P. B., Preliminary study of stability of flow from two ducts discharging into a common duct, *Nat. adv. Comm. Aero. tech. Note* 2417, 33 pp., July 1951.

In the theoretical analysis, the well-known theory of impinging jet, hodograph method, is used to find the flow field of two ducts discharging into a region of constant pressure (two-dimensional problems). The inherent indeterminancy of such a problem is avoided by introducing the Joukowsky hypothesis. Authors claim that the results indicate the flow to be stable. Reviewer believes that such an analysis does not indicate anything about stability of the flow because, in a stability analysis, a time-dependent disturbance must be considered.

In the experimental analysis, a two-dimensional water table with three different flow regimes for a symmetrical system of two ducts that converge and discharge into an expanded duct (or sink) was used. Instability of such flow configuration was found, which depends on the ratio of sink width to the duct width. The flow is unstable for large sink-width ratio. S. I. Pai, USA

464. Woods, L. C., A new relaxation treatment of flow with axial symmetry, *Quart. J. Mech. appl. Math.* **4,** part 3, 358–370, Sept. 1951.

To eliminate the disadvantage of "irregular stars" in the relaxation mesh near curved boundaries, the differential equations for axially symmetric inviscid incompressible and compressible flows are transformed so that the velocity potential φ and the Stokes stream function, Ψ, become the independent variables.

The radial distance r is taken as the dependent variable in the incompressible flow equation which makes the design of axially symmetric ducts particularly amenable to the method described. An example of such a design problem is presented in detail.

In the compressible flow equation, $\log (1/q)$, where q is the velocity, is the dependent variable. The compressible equation in this form can only be solved after the incompressible solution has been determined. Simon Ostrach, USA

465. van den Dungen, F. H., and Lahaye, Edm., On the relative permanent motion of a perfect fluid (in French), *Bull. Acad. roy. Belg. Cl. Sci.* (5) **36,** 12, 992–998, 1950.

Subject matter is the permanent, relative motion of a perfect fluid in contact with a noncylindrical, simply connected surface (S) without singularity, which carries out a uniform rotation $\bar{\omega}(\omega_x, \omega_y, \omega_z)$. The curl components (ξ, η, ζ) are related to the velocity components (u, v, w) by the equations

$$\xi = -2\omega_x + K\rho u, \quad \eta = -2\omega_y + K\rho v, \quad \zeta = -2\omega_z + K\rho w$$

where K is a constant which may be zero.

Beside these motions, there exist plane motions. Where (S) is a sphere, there are flow paths which consist of circles centered on the rotation axis; the velocity intensity may then be chosen arbitrarily.

Authors' considerations apply especially to the motion of atmospheric air masses.

From authors' summary by Pierre Schwaar, Switzerland

466. Berker R., On the impossibility of a viscous fluid, homogeneous or heterogeneous, having a Poinsot motion (in French), *Bull. tech. Univ. Istanbul* **3,** 1, 61–66, 1950.

It is shown that, when a mass of viscous fluid moves like a rigid body with a fixed center of gravity, this motion has a fixed axis of rotation and cannot be a general Poinsot motion. Conditions of the proof allow for compressibility, inhomogeneity of the fluid, and gravitational forces between the fluid elements.

L. J. F. Broer, Holland

467. Shchelkachev, V. N., Application of operational methods to the solution of the problem on motion of a viscous liquid in an elastic layer (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79,** 5, 751–754, Aug. 1951.

Author investigates problem of the two-dimensional axially symmetric flow of a viscous fluid through two concentric regions of different porosity toward a well or source located at the center. The source is assumed to draw fluid at a constant rate after the motion has been started from rest. The equations for the pressure are identical with the heat-conduction equation. The pressure is bounded at infinity, continuous and with specified ratio of normal derivatives at the interface, and with specified normal derivative at the well. The problem is set up by means of a Laplace transformation which is inverted asymptotically for very small and very large values of t. The resulting wall pressure agrees with that found by Everdingen and Hurst [*J. Petr. Technol.* no. 12, Dec. 1949]. Leon Trilling, USA

468. Imai, I., On the asymptotic behaviour of viscous fluid flow at a great distance from a cylindrical body, with special reference to Filon's paradox, *Proc. roy. Soc. Lond.* (*A*) **208,** 1095, 487–516, Sept. 1951.

The asymptotic behavior of flow at a considerable distance from an arbitrary cylindrical obstacle immersed in an otherwise uniform flow of an incompressible viscous fluid is considered on

the basis of the Navier-Stokes equations. Carrying out the Oseen type of successive approximation to the third stage, the expression for the stream function is exactly determined to the order of r^{-1}, where r is the distance from some fixed point in or near the cylinder. Then, by considering the conservation of linear and angular momenta of the fluid enclosed between the cylinder and a large contour, exact analytical formulas for the lift, drag, and moment acting on the cylinder are obtained. Thus, Filon's paradoxial results that the moment of a cylinder immersed in a viscous flow comes out to be logarithmically infinite with increasing extent of the flow region are given a complete explanation, and the usefulness of the Oseen type of successive approximation in dealing with the Navier-Stokes equations is confirmed.

From author's summary by J. M. Burgers, Holland

469. **Viguier, G., Circulation of a viscous incompressible fluid** (in French), *Bull. Acad. roy. Belg. Cl. Sci.* (5) **37,** 4, 397–405, 1951.

Author finds the time rate of change of circulation ($d\Gamma/dt$) in an incompressible, constant viscosity fluid with large velocity gradients. The linear relation between viscous stress tensor and rate-of-deformation tensor is supplemented with third-order velocity gradient terms, introducing two additional viscosity coefficients [AMR **1,** Rev. 487]. A general formula for $d\Gamma/dt$ is derived and compared with Carstoiu's result [AMR **1,** Rev. 314]. Two special cases are shown when $d\Gamma/dt = 0$: (1) $u_i = F_i(t)x_i$, and (2) $u_i = Q_i(x_j, x_k)$, where Q_i is a specified bilinear inhomogeneous function. Paper is a valuable contribution to the immense literature on circulation theorems, though reviewer feels that the omission of vectorial and/or tensorial notation and concept is not advantageous.

V. G. Szebehely, USA

470. **Meksyn, D., and Stuart, J. T., Stability of viscous motion between parallel planes for finite disturbances,** *Proc. roy. Soc. Lond.* (*A*) **208,** 1095, 517–526, Sept. 1951.

Earlier work by Meksyn [title source, **186,** 1006, 391–409, 1946, and AMR **3,** Rev. 295] and others is restated; new work is designed to find critical Reynolds number R above which two-dimensional oscillations of finite amplitude a will set in, and to find nature of these oscillations. Only even solutions are considered (i.e., for disturbances symmetrical with respect to center line of channel). Equations of motion are linearized, even though a is finite; this is justified *a posteriori.* Equation of mean motion is not linearized. Solutions are obtained by assuming a set of mean velocity profiles nearly parabolic and plotting R against a for each. Thus the lowest R, and corresponding a, mean profile and other parameters are found. $R = 2900$ is obtained as compared with 1000 pointed out by authors to be indicated by experiments of Davies and White [title source, **119,** 781, 92–107, 1928]. Even so, the value 2900 is lower (as expected physically) than 5050 calculated from infinitesimal disturbances, and so gives some improvement.

J. C. Cooke, Malaya

Compressible Flow, Gas Dynamics

(See also Revs. 459, 509, 512, 513)

471. **Moeckel, W. E., Flow separation ahead of blunt bodies at supersonic speeds,** *Nat. adv. Comm. Aero. tech. Note* 2418, 39 pp., July 1951.

A theory is developed to predict the flow near the nose of a blunt body placed in a boundary layer or wake, for cases of mixed sub- and supersonic upstream flow. Assuming wedge-shaped or conical separation regions and shock waves ahead of the body, it is found that there is a maximum ratio of body thickness to upstream boundary-layer thickness (for a chosen upstream Mach number) beyond which this type of flow cannot exist.

Two-dimensional experiments at Mach numbers from 1.73 to 2.02 show reasonable agreement with the theory for pressure in the separation region, in the range of body thickness where wedge-(cone) shaped separation regions occur. As body thickness approached the critical value, unsteady flow was noted. For slender bodies (order of magnitude of upstream boundary-layer thickness), less good agreement between theory and experiment is suggested to be due to interaction of shock wave and boundary layer.

William G. Cornell, USA

472. **Migotsky, E., and Morkovin, M. V., Three-dimensional shock-wave reflections,** *J. aero. Sci.* **18,** 7, 484–489, 504, July 1951.

Regular two-dimensional reflection of a shock is determined by the condition that the flow remain tangential to the boundary. Thus, the deflection angle across the oncoming shock must be equal and opposite in sense to the deflection angle across the reflected shock. This condition is only possible for a certain range of upstream Mach numbers and oncoming shock angles. This range lies between two curves, as represented in a diagram. Author considers only the range of regular reflection. The three-dimensional reflection can at every point of the surface of the body be reduced to the two-dimensional case, if, as in the sweepback principle, a plane cross section is considered, this being perpendicular to the shock and to the tangent plane at the body. Special cases considered are: A plane shock impinging upon an infinitely long circular cylinder, whose axis is parallel to the oncoming stream; a conical shock with axis parallel to the uniform stream impinging upon a plane wall, which is also parallel to the free stream. In these two cases, the same equations are valid. There always exists a set of points on the intersection curve for which regular reflection is not possible. The analysis of the regular reflection leads only to the initial direction of the reflected wave at the line of intersection. However, it is impossible to predict the shape of the reflected shock away from the body without a rather difficult analysis of the complete three-dimensional flow. For the plane shock reflecting from the cylinder there exists a region which has no counterpart in the conical shock reflecting from the plane wall. This is the region on the lee side of the cylinder. Instead of a reflected shock in this region an expansion wave is required. As a result, there is, on the lee side of the body, a "shadow" which weakens the shock. This region on the lee side of the body is critical in respect to a sharp thickening on separation of boundary layer. In the region of nonregular reflection the reflected shock should be relatively strong, and it is here that the greatest anomalies are to be expected; the boundary layer may also thicken and even separate.

Alb. Betz, Germany

473. **Cabannes, H., The problem of the detached shock wave for rotational flow** (in French), *Rech. aéro.* no. 21, 3–7, May-June 1951.

To solve problem of flow behind detached shock wave and around body for uniform supersonic flow before shock wave, author reverses normal approach of assuming body shape and solving for shock position and shape by assuming shock shape and solving for body shape. Assumed shock wave satisfies equation $X/R = \sum_{i=1}^{\infty} (\lambda_i/2i)(r/R)^{2i}$. Four functions, density, pressure, radial and axial velocity components, are known on shock waves and satisfy the first-order partial differential equations. Numerical solution is given for flow behind shock. Details of calculation are not given but are referenced. Method is used to determine

flow to series development around point of intersection of shock and axis. Results of solution to fourth-order terms are: (1) When λ_i is smaller than given number determined by free-stream Mach number, body is solid; where λ_i is larger than this number, body is annular. (2) For given free-stream velocity, there are several shock waves which will satisfy boundary conditions on body. Author states that this attack is the beginning of what might prove to be useful and readily usable method of analysis.

Horton Guyford Stever, USA

474. Zoller, K., On the structure of the shock wave (in German), *Z. Phys.* **130**, 1, 1–38, 1951.

Since shock-wave thicknesses predicted from continuous fluid theory become comparable to molecular mean free paths for strong shocks, use of kinetic theory is required. Paper presents extension of Burnett's work to higher approximation. Temperature and velocity profiles for gas composed of Maxwellian molecules are computed for $p_1/p_0 = 1.5$, 4, and 6.5. Second-order terms retained in solving conservation equations and Maxwell's transport equation are evaluated numerically and show that further approximations are probably required for shock strengths $p_1/p_0 > 5$. Inclusion of the second-order terms increases shock thickness for strong shocks to 2 to 3 times Becker's values. Recursion formulas for higher-order approximations are presented.

Wayland Griffith, USA

475. Greene, E. F., Cowan, G. R., and Hornig, D. F., The thickness of shock fronts in argon and nitrogen and rotational heat capacity lags, *J. chem. Phys.* **19**, 4, 427–434, Apr. 1951.

The method of Cowan and Hornig of studying the thickness of shock waves by measuring reflectivity for light has been improved and extended. A series of measurements are reported in argon for shock Mach numbers up to about 1.4, and comparison is made with the theories of Becker, Thomas, Mott-Smith [*Phys. Rev.* **82**, p. 885, June 15, 1951] and Wang Chang. Unfortunately, the measurements were not extended to a Mach number range (> 1.4) where these theories show marked disagreement, and the precision of the measurements is not sufficient to distinguish between these theories for low Mach numbers. However, it has become clear that all of these theories do, in general, give the right order of shock thicknesses for Mach numbers less than 1.4. A preliminary attempt to use the reflectivity technique to study the lag of the rotational energy of nitrogen has been made. Some evidence has been obtained that nitrogen is not completely equilibrated in shocks of the order of 20 mean-free-paths thickness ($M = 1.4$). Authors conclude from this that relaxation requires about 20 collisions. However, the process by which they derive this conclusion is not clear to the reviewer, and it is hoped that they will establish this quantity more precisley, as they propose in conclusion.

A. R. Kantrowitz, USA

476. Mitchell, A. R., Application of relaxation to the rotational field of flow behind a bow shock wave, *Quart. J. Mech. appl. Math.* **4**, part 3, 371–383, Sept. 1951.

The mixed subsonic-supersonic region behind a bow shock wave formed in a parallel supersonic flow of $M = 1.8$ against a blunt-nosed two-dimensional obstacle is evaluated by the relaxation method. The assumption of irrotationality behind the shock is removed to consider charges of entropy there. Significant differences are noted between previous calculations made on the assumption of irrotationality in the region and the present study.

Robert Simon, USA

477. Ryan, L. F., Experiments on aerodynamic cooling, Thesis, *Mitt. Inst. Aerodyn. ETH, Zurich* **18**, 50 pp., 1951.

Paper presents results of surface-temperature measurements on several insulated two-dimensional bodies over a range of subsonic free-stream velocities. Of particular interest are temperatures measured in separated-flow regions on airfoils at high angle of attack and at the base of several thick profiles. These temperatures were considerably lower than theoretical boundary-layer recovery temperatures and, in some cases, lower than tunnel static temperatures. Particularly low temperatures were associated with the appearance of strong alternating vortexes and whistling noise. Author speculates that low temperatures near surface in separated regions, or near center of wakes, are due chiefly to nonstationary kinetic-energy exchange processes involving large-scale vortexes. Equations derived on the assumption that heat conduction and viscosity are negligible indicate that such processes could account for observed effects, but no attempt is made to show that equations are quantitatively adequate. Short discussion is included of possible relationship between energy transfer processes in separated flow and in Hilsch vortex tube. Recovery temperatures in attached-flow regions agreed well with theoretical values based on local free-stream conditions.

W. E. Moeckel, USA

478. Frössel, W., Experimental investigation of compressible flow at and in the neighborhood of a convex wall (in German), *Mitt. Max-Planck-Inst. Strömungsforschung* no. 4, 105 pp., 1951.

In a rectangular tunnel of 39-mm by 190-mm cross section, one wall has a bump whose shape can be varied (circular arcs of 50-mm and 100-mm radius, and heights of 5 and 10 mm; circular arc with a straight tangential continuation in various directions). The height of the tunnel can also be changed. At different subsonic Mach numbers, the pressures over the model and along the walls have been measured. Furthermore, schlieren pictures with conventional light source and with spark illumination have been taken. Finally, the Pitot pressures are given. One thus obtains a very complete survey of the entire flow field. Main value of the report lies in the graphs of the flow field which may help in interpreting the physical phenomena of transonic flow. Also the experimental technique appears to be quite interesting.

Gottfried Guderley, USA

479. Lomax, H., Heaslet, M. A., and Fuller, F. B., Three-dimensional unsteady lift problems in high-speed flight—the triangular wing, *Nat. adv. Comm. Aero. tech. Note* 2387, 62 pp., June 1951.

Authors study title problem for wings suddenly sinking or pitching from rest position in still air. Simultaneously, with either motion, wings attain supersonic forward speeds.

Analysis of planforms with supersonic edges is complete; other cases are only partially so. Very narrow wings are treated by so-called slender wing theory.

Reviewer believes details of analysis (e.g., recognition of different areas of integration) are too extensive to be outlined here. It is sufficient to say the work seems complete and clear in its development. Curves give spanwise loading, lift build-up, center of pressure, etc., for several examples. Morton Finston, USA

480. Coale, C. W., Supersonic characteristics of rectangular horn balanced ailerons, *Douglas Aircr. Co. Rep.* SM-13718, 32 pp., Mar. 1950.

Aerodynamic characteristics of horn-balanced ailerons in supersonic flow are determined by standard, linearized, lifting-surface-theory methods. Total effectiveness is treated as the sum of the effects induced by two separate areas, a high-aspect-ratio surface along the trailing edge and a low-aspect-ratio surface adjacent to the wing tip. Graphs are presented for the lift and spanwise and chordwise center of pressure induced by the

low-aspect-ratio surface. Study of a typical planform indicates that good balance could be obtained without large variations of hinge moment-rolling moment ratio with Mach number.

Harvard Lomax, USA

481. **Watkins, Ch. E., Air forces and moments on triangular and related wings with subsonic leading edges oscillating in supersonic potential flow,** *Nat. adv. Comm. Aero. tech. Note* 2457, 44 pp., Sept. 1951.

Paper calculates the aerodynamic forces and moments of a family of harmonically oscillating triangular wings in such high-speed flows that the wing leading edges are subsonic and the trailing edges supersonic. The mathematical technique is essentially expanding a linearized potential in a power series in terms of a frequency parameter so that the integral equation thus formulated can be evaluated. The method can be applied for the first few terms without excessive labor. Thus it is an approximate method which is satisfactory for low frequency. No convergence proof of the series is given.

For certain ranges of flight Mach number and locations of the elastic axis of rotation, the triangular wings are liable to flutter under torsion. A criterion for this condition is given. It is shown that the torsional stability is better for the triangular wings of low aspect ratio than for those of high aspect ratio.

Chieh-Chien Chang, USA

482. **Hamaker, F. M., Neice, S. E., and Eggers, A. J., Jr., Similarity law for hypersonic flow about slender three-dimensional shapes,** *Nat. adv. Comm. Aero. tech. Note* 2443, 22 pp., Aug. 1951.

The similarity law for steady, inviscid hypersonic flow about slender three-dimensional shapes is derived in terms of customary aerodynamic parameters. To have similarity of flow, the law states that the lateral dimensions of the shapes in question and their angles with respect to the flight direction must be inversely proportional to their flight Mach numbers. A direct consequence of this law is that the ratio of the local static pressure to the free-stream static pressure is the same at corresponding points in similar flow fields.

The law is applied to the determination of simple expressions for correlating forces and moments acting on related shapes operating at hypersonic speeds. Shapes considered are wings, bodies, and wing-body combinations. In the special case of inclined bodies of revolution, these expressions are extended to include some significant effects of the viscous cross force.

Results of a limited experimental investigation of pressures acting on two inclined cones are found to check the law as it applies to bodies of revolution. Further investigation is necessary, however, to determine the range of applicability of the law.

From authors' summary by H. Lawrence, USA

483. **Lin, T. C., The effect of variable viscosity and thermal conductivity on the high-speed Couette flow of a semirarefied gas,** *Bull. Univ. Wash. Engng. Exp. Sta. Seattle* no. 118, Aero. Ser. no. 1, 26–60, 1951.

Using the Burnett equations for stresses and heat flux and Schamberg's relations for the slip velocity and temperature discontinuity at the wall, plane Couette flow in semirarefied gases is investigated. Schamberg's treatment of problem is extended by considering variations of viscosity and thermal conductivity with temperature. Author concludes that for equal wall temperatures the slip velocity, temperature jump, friction coefficient, and heat-transfer coefficient are increased due to these variations, particularly at larger values of the Knudsen number. In cases of unequal wall temperatures, the effects of these variations may be reversed depending on the ratio of wall temperatures and degree of rarefaction.

Alfred J. Eggers, Jr., USA

484. **Kaye, J., Keenan, J. H., and Shoulberg, R. H., Measurement of recovery factors and friction coefficients for supersonic flow of air in a tube,** Gener. discuss. heat transfer, Lond. Conf., Sept. 11–13, 1951, Sect. II. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., 5 pp., 1951.

Paper deals chiefly with the technical difficulties in measuring heat-transfer characteristics in tube flow at supersonic speed. Experimental values of recovery factor and local apparent friction coefficient (at an unspecified Mach number) obtained in alternative test equipment are compared with flat plate data in incompressible flow, and good agreement is noted.

R. Smelt, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 495, 511)

485. **Al'tshul', A. D., Ratio between the average and maximum velocity in turbulent pipe flow** (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **79**, 3, 405–406, July 1951.

Using author's formula for friction coefficient $C_f^{-1/2} = 1.8 \log (R/7)$ [AMR **4**, Rev. 2971] and the fact that the ratio of the difference between maximum U_c and mean U_m velocity to $(\tau_0/\rho)^{1/2}$ is independent of Reynolds number R, an obvious formula for U_m/U_c as function of R is deduced and checked with Nikuradse's experiments.

M. V. Morkovin, USA

486. **Emmons, H. W., The laminar-turbulent transition in a boundary layer. Part I,** *J. aero. Sci.* **18**, 7, 490–498, July 1951.

An experimental observation of the gradual spread of a localized turbulent region as it was transported by the flow of water running across a slightly inclined plate suggested that flow conditions in a boundary layer may be alternately turbulent and laminar, the fraction of time that the flow is turbulent at a downstream point depending on the frequency with which instantaneous turbulent sources are generated upstream and the rate at which they grow laterally. Based on some high-speed photographs that show the shape, rate of growth, and transport velocity of turbulent spots, and assuming that the frequency of generation of turbulent pockets is uniform over a flat plate up to its leading edge, the probability of occurrence of turbulence at various points on a flat plate was calculated and used to compute time-average drag coefficients in the transition region. The results are qualitatively in agreement with experimental friction data and with previous wind-tunnel measurements of the frequency of turbulent bursts passing a point on a flat plate.

R. L. Pigford, USA

487. **Stewartson, K., On the impulsive motion of a flat plate in a viscous fluid,** *Quart. J. Mech. appl. Math.* **4**, part 2, 182–198, June 1951.

Heuristic investigation of the boundary-layer flow resulting from impulsive starting of semi-infinite flat plate in its plane. Rayleigh solution (for approximately ∞ plate) for $x > Ut$ and exponentially asymptotic approach to Blasius solution for $t \to \infty$. Much of paper is concerned with vicinity of essential singularity found at $x = Ut$. Author has found no otherwise well-behaved solution without this singularity, but still presents these results as tentative. x is distance from leading edge, U constant velocity of plate, t time.

Two preliminary approximate approaches precede principal analysis: (1) Rayleigh's method, neglecting effect of transveral velocity, essentially the problem of temperature field around an impulsively heated semi-infinite plate parallel to an inviscid uniform fluid flow; (2) the von Kármán integral relation with simple geometrical similarity.

Solution of problems for a compressible boundary layer is indicated.

Reviewer notes that author seems to accept the surprising result that, with a parabolic differential equation, one part of the flow field ($x > Ut$) can be exactly unaware of something going on elsewhere, i.e., the existence of a leading edge. Singularity at $x = Ut$ may be a synthetic result of the (not clearly justified) restriction to solutions depending only on two variables.

Stanley Corrsin, USA

488. **Yamada, H., A method of approximate integration of the laminar boundary-layer equation,** *Rep. Res. Inst. Fluid Engng. Kyushu Univ.* **6,** 2, 87–98, Jan. 1950.

This is a short account of papers published in 1948 and 1949 in Japanese. Velocity u in a steady laminar boundary layer is approximated by a polynomial $u/U = a_1(x)\eta + a_2(x)\eta^2 + \ldots$ ($\eta = y/\delta$). Some of the coefficients are determined by boundary conditions, the others and δ must satisfy the equation $\Delta = uu_x - u_{y0}\int^y u_x dy - UU' - \nu u_{yy} = 0$. Investigation uses N "moment-equations": ${}_0\int^1 \Delta(x, \eta)\eta^n d\eta$, ($n = 0, 1, \ldots N - 1$) for N unknown functions. By this process Δ becomes zero N times, at least, between $\eta = 0$ and $\eta = 1$. Assuming $n = 0, 1, 2$ and a sixth-degree polynomial, boundary conditions determine a polynomial with three parameters: $u/U = F(\eta) + \omega G(\eta) + \vartheta H(\eta) + \varphi K(\eta)$, where F, G, H, K are known functions, ω being one sixth of the well-known Pohlhausen-Λ. Introducing this into Δ and moment equations, author arrives at a system of three ordinary simultaneous differential equations of the first order. Pohlhausen's equation follows for $\vartheta = \varphi = 0$. Calculations of some well-known examples with $\vartheta \pm 0$, $\varphi \pm 0$ show remarkable improvements over Pohlhausen solutions.

Fritz W. Riegels, Germany

489. **von Kármán, Th., Introductory remarks on turbulence,** *Inter. Union theor. appl. Mech. intern. astron. Union.*, Problems of cosmical aerodynamics, pp. 129–148, 1951.

Author derives the expression for the mixing length for a two-dimensional axially symmetric turbulent flow. As an example, the formula is applied to the formation of planets, assuming that the planets are formed by gathering mass from a region of diameter equal to the mixing length and that the radius of orbits of successive planets is 1.85. Result is that the mean velocity varies outward from the sun as $r^{-1/4}$. Limitations of the theory are pointed out. Remainder of the paper is a résumé of theories and measurements of isotropic turbulent fields.

A. M. Kuethe, USA

490. **Kawahara, T., Theory of turbulent boundary layer and its application** (in Japanese), *J. Soc. appl. Mech. Japan* **3,** 1–5, Jan. 1950.

Author determines the thickness of the turbulent boundary layer along a flat plate by using three integral relations, the first of which is the well-known momentum equation; the second and third are obtained by integrating the transport equations of mean turbulent energy and vorticity. In the second relation, the ratio Φ of the rate of viscous dissipation against the rate of work done by turbulent stress is assumed constant, whereas in the third relation, the production of vorticity by extension of vortex filaments is neglected. Using crude assumptions for the distribution of mean velocity, mean turbulent energy, and vorticity across the boundary layer, it is found that the thickness increases proportional to x^n, where x is measured from the leading edge and n is given by $(4\Phi - 1)/(4\Phi + 2)$. The results obtained are applied to the determination of skin friction, heat transfer, and evaporation.

Itiro Tani, Japan

491. **Townsend, A. A., The structure of the turbulent boundary layer,** *Proc. Camb. phil. Soc.* **47,** part 2, 375–395, Apr. 1951.

Author presents a comprehensive evaluation of an investigation by latest techniques of hot-wire anemometry of the turbulent boundary layer with zero pressure gradient. In a mature appraisal he surveys present knowledge of turbulent shear flows and makes judicious application also of pertinent results of the theory of isotropic turbulence. As a result, he creates a lucid description of the structure of the boundary layer.

Conditions within the boundary layer, he finds, are similar throughout the range investigated, $3630 < R_\delta < 5080$. Balances of turbulent energies established in terms of universal functions show basic differences in character, thereby delineating two distinct regions, namely, an outer region of free turbulence, where intermittency and spatially constant vorticity are encountered, and an inner region of turbulence of the type found in channels. In this region an intensive flux of turbulent energy under the action of turbulent pressure gradients as principal agent surges toward the wall, where direct dissipation, dispensing with the process of cascading to lower wave numbers, is concentrated in the "dissipation layer" adjacent to the laminar sublayer.

Length scales of turbulence derived from measured intensities and apparent shear stresses portray the structure of turbulence near the wall. Eddies seem attached to the wall, their size increasing proportional to distance from the wall. They resemble ellipses greatly elongated in direction of flow. Vorticity vectors point in direction of maximum rate of strain, at 45° downstream, which explains virtual equality of the cross-wind and down-wind turbulent velocity components while normal components are smothered close to the wall.

J. R. Weske, USA

Aerodynamics of Flight; Wind Forces

(See also Revs. 327, 504, 543)

492. **Nowakowski, W., A quick method of computing the longitudinal static stability of an aircraft** (in Polish), *Techn. Lotn.* **6,** 2, 31–33, June 1951.

The classical analytical-graphical method for the determination of the static-stability of an aircraft is indeed accurate, but demands proportionately much work and does not permit a quick discussion of separate influences on the magnitude of the stability and control of an aircraft. The analytical method presented leads, in part, to simplifications going further as the accuracy of its significance deviates from the accuracy of the classical analytical method. The aim of this note is to discuss a simple short method of equivalent accuracy for determining the static stability of an aircraft as practised at the Experimental Soaring Establishment (S.F.D.).

From author's summary by M. J. Thompson, USA

493. **Smiley, R. F., An experimental study of water-pressure distributions during landings and planing of a heavily loaded rectangular flat-plate model,** *Nat. adv. Comm. Aero. tech. Note* 2453, 40 pp., Sept. 1951.

A rectangular flat-plate model, 1 ft wide and 5 ft long, was subjected to smooth-water impact and planing tests. Landings were made at fixed trims of 6°, 9°, 12°, 15°, 30°, and 45° for a range of flight-path angles from approximately 2° to 20°, with beam-loading coefficients of 18.8 and 36.5. Planing runs were made at trims of 6°, 15°, 30°, and 45°.

Initial impact conditions and maximum pressures are presented in tables and figures for all impacts, together with time histories

of the pressure distribution, draft, vertical velocity, vertical acceleration, and wetted length.

The pressure coefficients based on the equivalent planing velocity appeared to be substantially independent of the deceleration of the model normal to the plate. The peak pressures were substantially equal to the dynamic pressure corresponding to the velocity of the peak-pressure point, for which velocity an approximate equation was derived. For wetted-length-beam ratios greater than approximately 1.5, this velocity was equal to the equivalent planing velocity for all flight-path angles; for wetted-length-beam ratios less than approximately 1.5, the ratio between this velocity and the equivalent planing velocity was unity for planing (0° flight-path angle) and increased with increase of flight-path angle. From author's summary

494. **Graham, E. W., A limiting case for missile rolling moments,** *J. aero. Sci.* 18, 9, 624–628, Sept. 1951.

A linearized theory is developed to study missile rolling moments. This is done by considering a cylinder with an infinite number of wings symmetrically arranged around it, and calculating the angular momentum which is added to the air, the rolling moment being a function of that quantity.

This theory, reminiscent of the simplified "momentum theory" of propellers through which an ideal efficiency was obtained, furnishes an upper limit for rolling moments and, in certain cases, agrees fairly well with experimental results. These cases are taken up in the discussion, and a table is included showing comparative values of C_{l_δ} and C_{l_p} and equilibrium rate of roll for delta-wing systems having 2, 4, and an infinite number of wings.

C. Svimonoff, USA

495. **Horton, E. A., Racisz, S. F., and Paradiso, N. J., Investigation of NACA 64, 2-432 and 64, 3-440 airfoil sections with boundary-layer control and an analytical study of their possible applications,** *Nat. adv. Comm. Aero. tech. Note* 2405, 40 pp., July 1951.

The results of these investigations indicate the following conclusions: (1) Large reductions in the wake-drag coefficient were obtained through a wide range of lift coefficient on the 32 and 40%-thick sections with relatively moderate flow coefficients and pressure-loss coefficients. Minimum total drag coefficients (including the drag-coefficient equivalent of the suction power) for the 32 and 40%-thick sections in the rough surface condition were 0.017 and 0.028, respectively.

(2) Wing characteristics as calculated from section data indicate that, for wings having a ratio of span-to-root thickness of 35 and a taper ratio of 0.2, the use of boundary-layer control increases maximum lift-drag ratio by 13%; that is, from 26.6 at a lift coefficient of 0.5 to 30.1 at a lift coefficient of 0.9, and increases aspect ratio for maximum lift-drag ratio from 12 to 20. With a parasite drag coefficient of 0.015 added to account for the drag of the fuselage, tail, etc., use of boundary-layer control increases maximum lift-drag ratio by 20%; that is, from 16.9 at a lift coefficient of 0.82 to 20.25 at a lift coefficent of 1.08, and increases aspect ratio for maximum lift-drag ratio from 12.4 to 21. These gains are based on calculations obtained by using section data corresponding to the rough surface condition and do not, therefore, depend on the attainment of extensive laminar layers.

Maximum lift coefficients of 2.57 and 3.49 were obtained for the 32 and 40%-thick sections without flaps for flow coefficients of 0.038 and 0.032, respectively.

The critical Mach numbers of the 32 and 40%-thick sections as determined from the theoretical pressure distributions at a lift coefficient of 0.4 were 0.527 and 0.462, respectively. These sections would, therefore, have application to relatively low-speed, long-range aircraft. From authors' summary

496. **Fraser, D., Orifice-type ice detector: preliminary icing tunnel tests of functioning as ice detector, rate-of-icing meter, and icing-severity meter,** *Nat. aero. Establ., Canada Lab. Rep.* LR-3, 16 pp., July 1951.

Tests were made in an icing tunnel to determine the sensitivity of a commercial orifice-type ice detector, and to assess its performance as a possible rate-of-icing meter and a thermal icing-severity meter (i.e., an instrument for measuring the amount of heat required for deicing). These tests were made over the small range of speed between 100 and 150 mph, at various temperatures, water contents, and droplet sizes.

The instrument was found to respond to an accretion of ice of 0.025 to 0.030 in. This sensitivity is sufficient for most purposes, but may not be adequate for some thermal methods of ice protection. Some increase in sensitivity can be obtained by altering the hole sizes in the detector head.

Indications of rate of icing were obtained with an accuracy probably within ±10% for normal types of icing. It is considered that the instrument is very well suited for use as a statistical type of rate-of-icing meter.

No reasonable indication of thermal icing severity (as distinct from rate of icing) was obtained. From author's summary

Aeroelasticity (Flutter, Divergence, etc.)

(See also Rev. 481)

497. **Garrick, I. E., Some research on high-speed flutter,** 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951. London, Roy. aero. Soc., 419–446.

Paper presents brief discussions of many topics currently of interest in the flutter field. These include (a) the sonic speed case, (b) oscillating pressure field of propellers, (c) wing flutter with various configurations including effects of body modes, and (d) propeller stall flutter. A list of 35 references is given.

Benjamin Smilg, USA

498. **Chuan, R. L., and Magnus, R. J., Study of vortex shedding as related to self-excited torsional oscillations of an airfoil,** *Nat. adv. Comm. Aero. tech. Note* 2429, 47 pp., Sept. 1951.

The relationship between the torsional oscillation and the shedding of vortexes was investigated for an NACA 0006 airfoil suspended elastically.

Two types of oscillation phenomena was found in the investigation. One type, exhibited by cases with angles of attack just above stall, persisted with increasing velocity without reaching any apparent limit within the range of velocity attainable in the present wind tunnel. The other type, exhibited by cases with higher angles of attack, only showed self-excited oscillations in a certain range of velocity, the range decreasing with increasing angle of attack. From authors' summary

499. **Buxton, G. H. L., and Minhinnick, I. T., Expressions for the rates of change of critical flutter speeds and frequencies with inertial, aerodynamic and elastic coefficients,** *Aero. Res. Counc. Lond. Rep. Mem.* 2444, 71 pp., Sept. 1945, published 1951.

Formulas are derived which give the rates of change of the critical flutter speeds and frequencies of an aeroelastic system (general number of degrees of freedom) with dynamical coefficients in the equations of motion. Through them, flutter speeds in the neighborhood of computed values may be obtained. Theory is illustrated by three examples. Unusual mathematical care and competence of the authors are evident.

R. M. Rosenberg, USA

500. Abichandani, K. P., and Rosenberg, R. M., Aileron flutter in a single degree of freedom, *Bull. Univ. Wash. Engng. Exp. Sta.* no. 118, *Aero. Ser.* no. 1, 72–76, 1951.

It is shown that conditions exist in potential flow of an incompressible medium, under which flutter involving the single-degree-of-freedom of rotation of the aileron about its hinge can occur. Existence of this flutter requires unusually large aerodynamic balance of the aileron. James E. Martin, USA

Propellers, Fans, Turbines, Pumps, etc.

(See also Revs. 435, 526, 566)

501. Brady, G. W., Propellers for high powers and transonic speeds, 3rd Anglo-Amer. aero. Conf., Brighton, Sept. 4–7, 1951. London, Roy. aero. Soc., 613–638.

A general discussion is presented of the characteristics, performance, and design of transonic and supersonic propellers. In line with purpose of the paper, author recommends future trends to be followed in the development of transonic and supersonic propellers. The treatment is thorough, dealing with all phases of development, such as performance, structure, design, noise level, over-all performance, and testing techniques.

It is unfortunate that references to existing literature devoted to the various problems are not included in the discussions. Leonard Goland, USA

502. Vogeley, A. W., Axial-momentum theory for propellers in compressible flow, *Nat. adv. Comm. Aero. tech. Note* 2164, 12 pp., July 1951.

Present edition of the paper cancels some results of an earlier one [AMR 4, Rev. 2193] in cases of free-stream Mach number —1, as their significance is found to be not clear. A difference in efficiency between compressible and incompressible flow conditions given by a graph in the earlier edition is now estimated to be zero within the accuracy of calculations. Einar Hogner, Sweden

503. Fox, N. L., Analytical solutions for gross thrust change and weight flow ratio due to a jet ejector pump, *Douglas Aircr. Co. Rep.* SM-13881, 27 pp., Dec. 1950.

To provide adequate cooling air for turbojet-engine installations it is frequently necessary to provide pumps of various kinds. Present report considers the effect, upon the gross thrust, of the use of a jet pump operating upon energy derived from the turbojet exhaust.

The analysis assumes the addition of a secondary shroud for use of the jet pump, and the effect of this shroud upon gross thrust is calculated for several special cases, which can be tabulated as follows: Incompressible flow—(1) no mixing, (2) complete mixing, (3) partial mixing; Compressible flow—(4) no mixing. For each of these cases this change in gross thrust and the change in weight flow due to the addition of the secondary shroud are calculated in terms of area and pressure ratios of the primary and secondary system.

The analysis shows the importance of maintaining low total pressure losses in the secondary inlet scoop. Also, in order to operate efficiently at take-off and at high Mach numbers, it will be necessary to have a variable geometry cooling system. It is further shown that the mixing-section length which produces the maximum gross thrust increase may also give the required cooling, providing the viscous effects on the walls do not invalidate the conclusions drawn from these simplified calculations. Morton Alperin, USA

504. Klein, H., The thrust and drag penalties on a jet engine installation due to cooling flow, *Douglas Aircr. Co. Rep.* SM-13862, 14 pp., Nov. 1950.

The change in net thrust of a turbojet with a cooling shroud added is presented by analysis in terms of (1) the ratio of intake momentum to basic engine net thrust; (2) the ratio of cooling air flow to engine air flow; and (3) the fractional change in gross thrust due to the presence of the secondary shroud and cooling flow. Although test data are required to evaluate the gross thrust-change term, theoretical values are derived assuming, first, no mixing and then complete mixing of the cooling and main streams. For the pressure ratios used, thrust gains, rather than losses are shown. W. T. Olson, USA

505. Foa, J. V., Single flow jet engines—a generalized treatment, *J. Amer. Rocket Soc.* 21, 5, 115–126, 131, Sept. 1951.

Author presents a generalized treatment of air-breathing jet engines in which all the working medium undergoes the same processes. The purpose of the treatment is to (a) permit a comparison among different types of jet engines; (b) focus attention on the effect of the various processes within each engine, thereby detecting specific improvement possibilities within the engine.

Author makes simplifying assumptions which, in the opinion of reviewer, do not negate the broad conclusions reached in the study. Conclusions indicate that present turbojet and ramjet performance characteristics are closer to optimum performance than pulse-jet performance characteristics. The overcoming of present high-speed operating difficulties in pulse-jet engines could pay rather handsome dividends. J. F. Manildi, USA

Flow and Flight Test Techniques

(See also Revs. 454, 457, 479, 523)

506. Durbin, E. J., Optical methods involving light scattering for measuring size and concentration of condensation particles in supercooled hypersonic flow, *Nat. adv. Comm. Aero. tech. Note* 2441, 28 pp., Aug. 1951.

To obtain quantitative information that may lead to an understanding of condensation of the components of air in a hypersonic wind-tunnel flow, optical methods for measuring size and concentration of condensation particles are studied. Measurements of intensity of either scattered or transmitted light may be used, but light-transmission method is better because both concentration and size can be determined from a single set of measurements. Air was expanded through a nozzle which produced a temperature ratio of 0.096 (design Mach number of about 7), and it was found that the particle radius was of the order of 5.0×10^{-6} cm and that the concentration was of the order of 10^{10} particles per cm³. A similar study of optical properties of small particles but for purposes of flow visualization has been made by Korbacher [*Ministry of Supply, Natl. Gas Turbine Establ.*, Rep. R.40, 1948]. Wallace F. Davis, USA

507. Lieneweg, F., Temperature measurements (Temperaturmessung), Leipzig, Akademische Verlagsgesellschaft, 1950, 219 pp., 78 figs., 22 tables. DM 15.

A correct temperature measurement is necessary not only in scientific research but also in practice during melting and heat treatment of metals and in organic chemical plants. Considerable progress has been made in the field of temperature measurement in the last decade, in the technique as well as in instrumentation. Proper use of the sensitive instruments not only requires an exact knowledge of the error sources, but in addition, the engineer must know the principles of heat transmission which sub-

stantially influence the temperature measurements. He must also know the features which are decisive in the construction of the apparatuses, and in the carrying out of the measurements. Finally, he must be able to picture the measurement errors and the influence of connected instruments on the temperature measurements.

The book answers all these questions clearly, understandably, and exhaustively. It contains, besides the indicated theoretical explanations, numerous nomograms, sets of curves and tables which permit a simple calculation of the measurement error and the indication lag. It also contains valuable indications on the use of protective materials in gases, vapors, fluids, and melting.

The book can be well recommended as a text and reference book to all those who conduct temperature measurements.

Frick, Germany

508. **Daish, C. B., Fender, D. H., and Woodall, A. J., A note on the use of resistance thermometers of rapidly changing temperatures,** *Phil. Mag.* (7) **41**, 318, 729–730, July 1950.

509. **Leah, A. S., Rounthwaite, C., and Bradley, D., Some extension in the use of resistance thermometry in the study of gaseous explosions,** *Phil. mag.* (7) **41**, 316, 323; 468–477, 1289–1291; May, Dec. 1950.

A modified technique for recording resistance-wire temperatures is described. By using plain and quartz-coated wires at the resistance elements in explosions, a possible method of investigating the course of the reactions occurring within the flame reaction zone is suggested. The corrections to be applied to estimate the true flame gas temperature for the quartz-coated wire records are evaluated.

A method of determining the rate of catalytic heating on the plain wires is outlined, and results from a typical explosion of a 90% CO + 10% O_2 mixture at 0.4 atmosphere initial pressure are shown. Thickness of the reaction zone in the early stages of the explosion is estimated to be 4 cm. From authors' summary

510. **Schoen, J., Temperature measurements in gas flow,** (in German), *Arch. tech. Messen* no. 187, T84–T85, Aug. 1951.

Author reviews different types of instruments and possible errors. Methods are given to measure the stagnation temperature, especially with a thermocouple in a streamlined probe and to determine the error due to the stagnation effect. References are made to German literature. R. Betchov, USA

511. **Townsend, A. A., The passage of turbulence through wire gauzes,** *Quart. J. Mech. appl. Math.* **4**, part 3, 308–320, Sept. 1951.

Reduction of turbulence velocity fluctuations upstream and downstream of fine-mesh wire gauzes have been measured. Results would be useful in the design of settling lengths of wind tunnels. Measurements with a hot-wire anemometer give results generally in agreement with Taylor-Batchelor theory, where attenuation is a function of pressure and refraction coefficients. As predicted, the gauze has less effect on the transverse than on the longitudinal components. Turbulence behind the gauze is anisotropic but less than theory predicts, and trend toward isotropy downstream is weak. However, local isotropy is quickly reached since measurements show $(\partial u/\partial x)^2 = \frac{1}{2}(\partial v/\partial x)^2$. Measurements of reduction of turbulence upstream of gauze is in closer agreement with Taylor-Batchelor theory. Paper is of additional value since excellent discussions describe reasons for variance between theory and experiment.

Louis M. Laushey, USA

512. **Cunningham, R. G., Orifice meters with supercritical compressible flow,** *Trans. Amer. Soc. mech. Engrs.* **73**, 5, 625–637, July 1951.

Experiments on discharge coefficients KY for flow of air (2-in. pipe-meter) and steam (3-in. pipe-meter) at pressure ratios from unity to 0.13. Diameter ratio in both cases was 0.15. K is the "incompressible" coefficient and Y the expansion factor. Y was plotted against orifice pressure ratio. Subcritical values agree well with the linear ASME equations. Supercritical values form straight lines intersecting the ASME lines at a pressure ratio of 0.63 or 0.77 (depending on position of pressure taps).

Effects of high approach velocity were investigated for flow of air at pressure ratios from unity to 0.2 and for diameter ratios from 0.2 to 0.8.

Accuracy of experimental curves is discussed. A theoretical solution for the case of supercritical flow (previously presented by the author) was compared with the air data. Agreement was within 1–2%. N. Holm Johannesen, England

513. **Holder, D. W., and North R. J., Observations of the interaction between the shock waves and boundary layers at the trailing edges of aerofoils in supersonic flow,** *Aero. Res. Counc. Lond. curr. Pap.* 53, 5 pp., 7 figs., Dec. 1950, published 1951.

514. **Klein, H., Dimensionless parameters for airplane model testing,** *Douglas Aircr. Co. Rep.* SM-14025, 9 pp., Mar. 1951.

Thermodynamics

(See also Revs. 449, 475)

515. **Meghreblian, R. V., Approximate calculations of specific heats for polyatomic gases,** *J. Amer. Rocket Soc.* 21, 5, 127–128, 131, Sept. 1951.

Simplified method is given for calculation of approximate values of specific heats of polyatomic molecules, which occur in combustion processes in rockets, and for which precise spectroscopic data are unavailable. Comparison of experimental and approximate values of specific heat is given for ten compounds.

Joseph Kaye, USA

516. **Gol'denberg, S. A., Process of turbulent heterogeneous combustion in a high temperature region** (in Russian), *Izv. Akad. Nauk SSSR Otd. tekh. Nauk* no. 7, 1025–1030, July 1951.

The process of a turbulent heterogeneous combustion in high-temperature zones is of particular interest because of associated diffusion delays of chemical reactions. In the described tests this delay occurred at the temperatures of carbon above 900 C. Experiments confirmed the relationship of such a combustion process obtained analytically by the use of the known Nusselt formula. It was also shown that the experimental finite length of the carbon tube offers no limitation for accurate calculations. The length of the oxygen zone in the high temperature region is proportional to Reynolds number and the tube diameter.

L. M. Tichvinsky, USA

517. **Thring, M. W., The temperature distribution along a radiating gas stream in which heat is being liberated by a chemical reaction,** *Proc. roy. Soc. Lond.* (A), **208**, 1093, 247–262, Aug. 1951.

The variation of flame temperature Y with distance X along a slowly burning flame is calculated theoretically, assuming the flame consists of a central jet of fuel which neters at a tempera-

ture of the heat sink T and entrains combustion air at a rate constant with respect to distance along the flame. The entrained air is assumed to react rapidly with the fuel stream, and the products of reaction remain in the fuel stream so that the flame temperature rises at a rate dY/dX which falls off as the heat capacity of the stream increases. For no heat loss from the fuel stream the temperature-distance curve is shown to be a rectangular hyperbola whose curvature at any point increases as q, the ratio of the heat capacity of the initial fuel stream to that of the final combustion products, decreases. In other cases, heat transfer is presumed to take place by convection or radiation between the fuel jet and heat sink with a heat-transfer coefficient assumed constant for a cylindrical flame, and proportional to distance from the inlet for a conical flame. It is shown that the flame temperature must increase monotonically until combustion is complete for the cylindrical flame, whereas the temperature in the conical flame may fall off at an earlier stage. The shape of the temperature-distance curve for convective heat transfer is dependent only on q and ratio L/L_0 (where L is length for all combustion air to be entrained, and L_0 is length in which all combustion energy would be transferred to the surroundings if the flame remained at the adiabatic combustion temperature T_a). With radiative heat transfer the shape of the curves depends on q, L/L_0, and the ratio T/T_a.

Reviewer believes theoretical contributions of this type are highly desirable but does not believe the equations could be considered "working" equations since many of the assumptions are highly idealized. Experimental application seems very difficult to apply, particularly as regards the evaluation of emissivity, since the emissivity would vary across and along the flame.

There seem to be a number of errors (probably typographical) in the article. A. W. Jones, USA

518. Zeldovich, Y. B., On the theory of combustion of initially unmixed gases, *Nat. adv. Comm. Aero. tech. Memo* **1296,** 20 pp., June 1951.

Paper is a theoretical treatment of the laminar diffusion flame. Initially, the important simplifying assumptions used are: (a) No heat is lost from the flame by radiation; (b) the diffusion coefficient of each substance and the coefficient of heat conductivity are all equal to each other; (c) the reaction is fast so that the reaction zone is thin enough to treat as a geometrical surface. From diffusion and convective transfer of reactants a relation is given that locates the flame surface where the reactants are in precise stoichiometric ratio and disappear through reaction. [Burke and Schumann, *Indust. Engng. Chem.* **20,** 10, 998–1004, Oct. 1928, have solved this general equation for one case.] Zeldovich then derives general expressions for the distribution of reaction products and of temperature in terms of the reactant concentrations in the burning gases. Because of the simplifying assumptions, the distribution of the concentrations of the products and the temperature of the flame correspond precisely to the combustion of a stoichiometric mixture.

With the further assumption that the rate of chemical reaction is insufficient to keep up with the supply of fresh fuel and oxygen to the flame surface, a widening of the reaction zone occurs, followed by extinction of the flame at a critical value of flow. An analysis is made of the critical amount of substance that will react on unit flame surface in unit time if a simple reaction-rate equation holds. The result shows that the maximum intensity of combustion of a mixture and of unmixed gases, if the mixing is sufficiently intensified, is of the same order. The maximum possible lowering of the temperature of the reaction zone before flame extinction is equal to $3\ RT^2/E$, where R is the gas constant, T the theoretical flame temperature, and E the activation energy.

Walter T. Olson, USA

519. Braga, L., Heat recovery in heat pumps (in Italian), *Termotecnica* **5,** 9, 389–401, Sept. 1951.

The heat-pump integral with a heat engine employing, in turn, an electric motor, steam turbine, illuminating gas engine, Diesel engine, and ammonia absorption system is analyzed thermodynamically, employing in part a definition proposed by author for efficiency of the pump-engine ensemble. Economic considerations are referenced to simple combustion as a source for space heating. M. J. Goglia, USA

Heat and Mass Transfer

(See also Revs. 330, 484, 507)

520. Lineĭkin, P. S., On equations of heat convection (in Russian), *Prikl. Mat. Mekh.* **15,** 4, 433–438, July-Aug. 1951.

Author investigates the question of convergence of a process of successive approximations with respect to the problem of free heat convection in plane motion. He starts from the system of four equations (one equation of continuity of incompressible liquid, two equations of steady motion of a viscous liquid with term αT added to account for the force of thermal buoyancy, and one equation of heat convection, the term due to viscous dissipation being included). He shows how it can be reduced to a system of two partial differential equations for the stream function and the temperature, respectively, a system which, in turn, leads to a system of nonlinear integrodifferential equations in case the boundary conditions (vanishing velocity and given temperature along the wall) are given. This system now can be solved by successive approximations, this method being equivalent to a development with respect to the parameter α. The question arises whether the process will converge. By applying classical considerations based on certain regularity conditions for the boundary values, author establishes a sufficient condition for the convergence, a condition which is, of course, an upper limit for the values of α. He concludes by pointing out that, for practical applications, it would be important to raise the upper limit still further. A. von Baranoff, France

521. Levich, V. G., Theory of diffusion processes in a moving fluid (hydrodynamics at high Prandtl numbers) (in Russian), *Dokladi Akad. Nauk SSSR (N.S.)* **78,** 6, 1105–1108, June 1951.

Author draws attention to fact that the Prandtl number for diffusion is about a hundred times larger than the Prandtl number for heat conductivity because the diffusion coefficient is about 100 × the coefficient of heat conductivity. He lists for various conditions how the Nusselt number depends on the Prandtl and Reynolds number. Paper is based on four theoretical papers by author in the Russian *J. phys. Chem.* [**18,** p. 335, 1944; **22,** pp. 575, 711 and 721, 1948]. D. ter Haar, Scotland

522. Tinker, T., Shell side characteristics of shell and tube heat exchangers. I, II, III, Gener. discuss. heat transfer Lond. Conf., Sept. 11–13, 1951, Sect. II. London, Instn. mech. Engrs.; New York, Amer. Soc. mech. Engrs., **28 pp.**

Purpose of paper is to analyze the effect of the various flow passages through a commercial shell-and-tube heat exchanger on the over-all heat transfer and pressure drop characteristics of the exchanger. From a study of the flow pattern, including various leakage and by-pass currents, a concept of "effective area" is developed. A method of evaluating the effective area in terms of the heat-exchanger dimensions and certain fluid-flow resistances is derived.

Paper consists of three parts. Part I develops the theory of the effective area. Part II applies the analysis of part I to an analy-

sis of the flow pattern on the shell side of a shell-and-tube heat exchanger. Results of tests on 11 different heat exchangers through a 1000-fold range of Re numbers are reported. Author's method of correlating variables on basis of effective area appears to give better coordination of the data. Part III reports on the result of tests made on a heat exchanger when the mechanical clearances and other proportions of a typical shell-and-tube exchanger are varied. For example, author reports that an increase of $^1/_{64}$ in. in baffle hole clearance reduces the outside cross flow coefficient of heat transfer by 10%.

Reviewer feels that the paper should prove useful in the design of economical heat exchangers, and that author's picture of the flows within a shell-and-tube exchanger explains some of the inconsistencies arising in this field. William A. Wolfe, Canada

523. **Fischer, J., The stationary temperature of moderately long wires traversed by current** (in German), *Arch. Elektrotech.* **40**, 3, 141–171, 1951.

An analytical study is made of the temperature distribution along wires which are conducting electrical current under the following steady-state conditions: (1) Wires of finite length; (2) symmetrical mounting of the wire; (3) the properties of the wire are functions of the temperature; (4) wires are located in vacuum, gaseous, or liquid environments. Detailed numerical examples are included. Analysis is directly applicable to problems associated with vacuum and gas-filled tubes, filaments, and various types of hot-wire instruments. W. L. Sibbitt, USA

524. **Rubinshteĭn, L. I., On heat propagation in a two-phase medium in presence of cylindrical symmetry** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **79**, 6, 945–948, Aug. 1951.

Mathematical discussion of the following equation and boundary conditions:

$$u_{xx} + u_x/x = \alpha u_t; \; \alpha = a^{-2}, 0 < x < y(t); \; \alpha = 1, y(t) < x < 1;$$
$$u(l, t) = f(t); \; u(x, 0) = \varphi(x); u[y(t), t] = 0;$$
$$\dot{y}_{\epsilon \to 0} = u_x[y(t) + \epsilon, t] - u_x[y(t) - s, t]$$

D. ter Haar, Scotland

525. **Storm, M. L., Heat conduction in simple metals,** *J. appl. Phys.* **22**, 7, 940–951, July 1951.

The differential equation for one-dimensional heat conduction, $(\partial/\partial x)(K \cdot \partial T/\partial x) = S \cdot \partial T/\partial t$ (T is temperature at time t and position x, K thermal conductivity, $S = \rho c_p$, ρ density, c_p specific heat at constant pressure) is a nonlinear one for $K = K(T)$ and $S = S(T)$. Author transforms it to a linear one assuming that $(d/dQ)\log(S/K)^{1/2} = \text{const.}$ Herein $Q = {}_{T_0}\int^T [K(\lambda)S(\lambda)]^{1/2}\, d\lambda$. On the bases of the theory of solids and available experimental data author shows that this assumption holds very well for "simple" metals, such as Al, Ag, Na, Cd, Zn, Cu, Pb, Fe, 0.8% carbon steel, nearly always up to about the melting point.

A numerical example is given, the result of which is compared with that of the linear equation (K and S constant). For the case in which the coefficient of diffusion $D = D_0 e^{-ac}$ (c concentration, a constant), the diffusion equation $(\partial/\partial x)(D \cdot \partial c/\partial x) = \partial c/\partial t$ can be handled in the same manner.

H. Wijker, Holland

526. **Sochat, D., Approximate method for calculation of temperature distribution in disks and blades of gas turbines** (in French), *Bull. Assn. tech. marit. aéro.* no. 49, 785–811, 1950.

Described method is based on assumption of one-dimensional heat flow and the division of the disk and blades into finite annular sections. Procedure is generalized algebraically to some extent to permit easier computation. Method permits variation of convective coefficients of disk and blade shapes, of material and physical properties, and of position and extent of external cooling. Several numerical examples indicate the effects of the several variables on the temperature distribution. The convective coefficients for the disk and blade surfaces were computed using the relations of Schultz-Grünow [*Z. angew. Math. Mech.* **15**, 191–204, July 1935] and of Colburn [*Trans. Amer. Inst. chem. Engrs.* **29**, p. 174, 1933], respectively. Carl Gazley, Jr., USA

527. **Vernotte, P., Fundamental aspects of thermokinetics** (in French), *Publ. sci. Min. Air, France, Notes tech.* 41, 45 pp., 1951.

In this publication, 16 pages of preface are devoted to quasi-metaphysical discussion of the basic meaning or "spirit" of science. The connection of this rambling, verbose, anecdotal preface to main work is not clear. Main work is in three chapters. Chapter 1 gives a partial résumé of mathematical theorems concerning transient heat-flow phenomena established by Fourier. Mathematical derivations are omitted. Since the work is a condensation of 18 lectures, detailed mathematical logic is omitted. In discussion, the slowness of transient heat flow in natural processes is emphasized. Chapter 2 discusses some practical consequences of the principles outlined in chapter 1; for example, the insulation properties of Dewars and errors in thermocouple calibrations are treated in extreme detail. Chapter 3 gives description of mathematical methods of solution of the Fourier equation for the diffusion of heat, with application to a few simple cases, as, for example, one-dimensional heat flow through an infinite wall. In reviewer's opinion, the work forms an interesting introduction to the literature of heat transfer, but it suffers from difficulties introduced by excessive brevity of treatment. J. G. Daunt, USA

528. **Goldenberg, H., A problem in radial heat flow,** *Brit. J. appl. Phys.* **2**, 8, 233–237, Aug. 1951.

Solution to the radial heat-flow problem in a homogeneous infinite medium, with a spherical region $0 \leqslant r \leqslant a$ where, at $t > 0$, heat is produced at a constant rate per unit volume. Assuming spherical symmetry, author solves the time-dependent heat equation by applying the Laplace transformation to the temperature function $V(r, t)$. Carslaw and Jaeger ["Conduction of heat in solids," p. 287, 1947] obtained the solution to this problem for the Laplacian form of the temperature function and a particular solution for the temperature at $r = 0$. Author devotes most of his work to obtaining general and particular solutions of temperature function $V(r, t)$ from its Laplacian form already obtained by Carslaw and Jaeger. S. Eskinazi, USA

529. **Mohanty, S. R., A relationship between heat conductivity and viscosity of liquids,** *Nature* **168**, 4262, p. 42, July 1951.

Andrade's viscosity and Osida's heat-conductivity formulas are combined, resulting in $MK/\eta = 6$, where M is molecular weight, K heat conductivity in calories, and η viscosity in poises. For seven liquids at the boiling point, the average value of MK/η is 10.8. Author's explanation of discrepancy: scarcity of reliable data, especially regarding K. V. G. Szebehely, USA

530. **Hoge, H. J., and Lassiter, J. W., Critical temperatures, pressures, and volumes of hydrogen, deuterium, and hydrogen deuteride,** *J. Res. nat. Bur. Stands.* **47**, 2, 75–79, Aug. 1951.

Experimental and data-analyses techniques are described. A unique method of successive approximations is presented for obtaining critical point utilizing reduced pressures, temperatures, and volumes. Reduced isothermes (T/T_c) from 0.99557 to 1.05055 are plotted on a reduced pressure (p/p_c)-reduced volume (V/V_c) chart. The following critical point data are presented:

	T_c °k	p_c mm Hg	$V_c$cm³ mole⁻¹	p_cV_c/RT_c
$e - H_2$	32.994	9,705	65.5	0.309
HD	35.908	11,130	62.8	0.312
$e - D_2$	38.262	12,374	60.3	0.312

K. R. Wadleigh, USA

531. von Ubisch, H., On the conduction of heat in rarefied gases and its manometric application. I, II, *Appl. sci. Res.* (*A*), **2**, 5–6, 364–430, 1951.

The article covers design and performance of hot-wire (Pirani-type) gages for measuring gas pressures in the range between one-thousandth and several millimeters of mercury. This is a valuable review of the theoretical and experimental aspects of design and operation of Pirani-type gages. Heat-transfer measurements from hot wires in 25 different gases are reported.

E. D. Kane, USA

532. Berman, R., The thermal conductivities of some dielectric solids at low temperatures, *Proc. roy. Soc. Lond.* (*A*), **208**, 1092, 90–108, Aug. 1951.

An apparatus is described in which the thermal conductivity of solids can be determined at any temperature between 2 and 90 K. Several glasses and dielectric crystals have been measured. It had previously been found that, at high temperatures, the conductivity of glasses is proportional to the specific heat, but at low temperatures it falls off more slowly than the specific heat. Present experiments show that there is a temperature region in which the conductivity is nearly independent of temperature.

Effect of lattice defects in crystals was studied by measuring the thermal conductivity of a quartz crystal before and after successive periods of neutron irradiation. After prolonged irradiation, the conductivity approached that of quartz glass. Subsequent heating produced a substantial recovery in conductivity. Results can be explained by the theory developed by Klemens. Further measurements made on a corundum crystal confirm importance of the "Umklapp" process, postulated by Peierls, in causing thermal resistance.

From author's summary by William J. Anderson, USA

533. Krishnamurti, D., Evaluation of the specific heat of diamond from its Raman frequencies, *Proc. Indian Acad. Sci.* (*A*), **34**, 2, 121–126, Aug. 1951.

The specific heat of diamond is evaluated from the knowledge of its vibration spectrum obtained principally from Raman effect studies. The vibration spectrum is known to consist of eight discrete monochromatic frequencies followed by a continuous spectrum of elastic vibrations. Accordingly, the specific heat is expressed as the sum of eight Einstein functions, supplemented by three Debye functions representing, respectively, the three types of elastic vibration possible in the crystal. A close agreement is found between the calculated and the experimental values over the entire range of temperatures between 70 K and 100 K, which is all the more significant in view of the calculations being completely independent of the specific heat data themselves.

From author's summary

534. Verschoor, J. D., and Greebler, P., Heat transfer by gas conduction and radiation in fibrous insulations, Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-54, 7 pp.

Thermal conductivity measurements were made on samples of an experimental glass fibrous insulation ranging in density from 0.5 to 8.4 pcf. Tests were carried out at atmospheric pressure with four different gases in the insulation samples, and the thermal conductivity with air was studied over a pressure range of 1 micron to 760 mm of Hg. Gas conduction is the most important mechanism of heat transfer. A theory of gas conduction in fibrous insulations was developed and agrees well with experimental results. Theoretical considerations of heat transfer by radiation were confirmed by the experimental thermal-conductivity values at low pressures. Methods are discussed of producing considerable reduction in the thermal conductivity of fibrous insulations.

From authors' summary

Acoustics

535. Carter, A. H., and Williams, A. O., Jr., A new expansion for the velocity potential of a piston source, *J. acoust. Soc. Amer.* **23**, 2, 179–184, Mar. 1951.

Paper gives an approximate paraxial expansion, and also a rigorous expansion for the velocity potential generated by an oscillating piston in an infinite, rigid wall. Both expansions are developed from Schoch's line-integral expression for the velocity potential, and both are suitable for numerical computations for a high frequency source.

The authors' rigorous expansion consists of a series of half-order Hankel functions in kz and polynomials in x/a; k is the propagation constant, a the piston radius, z the axial, and x the radial coordinate of a field point. Reviewer has been informed that the domain of convergence of this expansion is somewhat smaller than was stated in the paper, and will be the subject of a forthcoming communication in the *J. acoust. Soc. Amer.*

Authors' paraxial expansion in powers of x/a is not strictly correct to terms of second order. It may be improved by redefining β to be: $\beta \equiv kx^2 (1 - a^2/2Z_a^2)\, Z_a$, where $Z_a = (Z^2 + a^2)^{1/2}$. Still further refinement is possible using methods of this paper.

H. G. Elrod, Jr., USA

536. Middleton, D., The distribution of energy in randomly modulated waves, *Phil. Mag.* (7), **42**, 330, 689–707, July 1951.

Paper treats power spectra of amplitude, phase, and frequency linearly modulated carriers. Emphasis is given to series expansions of the disturbances to determine the character of the resulting modulation. Although paper contains tedious mathematical considerations, author interprets results lucidly.

Thomas Caywood, USA

537. Cunningham, W. J., The growth of subharmonic oscillations, *J. acoust. Soc. Amer.* **23**, 4, 418–422, July 1951.

Subharmonic oscillations at one half the frequency of excitation may appear in certain types of oscillating systems, among which is the direct-radiator loudspeaker. These oscillations occur at very nearly the resonant frequency of the system when the parameters of the system are made to vary at twice this frequency. The rate of growth of the subharmonic depends upon the amount of variation of the parameters relative to the dissipation in the system. If the dissipation is small, the rate of growth may be large. In the loudspeaker, conditions are such that the rate of growth is usually small for typical conditions of operation.

From author's summary by J. W. Cohen, Holland

538. Brekhovskikh, L. M., Diffraction of acoustic waves on an uneven surface (in Russian), *Doklady Akad. Nauk SSSR* (*N.S.*) **79**, 4, 585–588, Aug. 1951.

A study is made of the general problem of determining the sound field produced at any point in space by the scattering of sound waves from a surface agitated by ripples, the equation of the surface being represented by a function periodic with respect

to X_1 and X_2 ($X_1X_2X_3$ the rectangular coordinates of a point on the surface).

An expression is found for the amplitude associated with the different wave lengths of the spectrum of sound waves scattered from a surface agitated by ripples represented by a function periodic with respect to X_1. The expression obtained agrees with that of Rayleigh for the special case of plane waves incident normally on a surface agitated by ripples whose amplitude is small compared with the wave length of sound. The method can be extended to the case of a surface with ripples represented by a function periodic with respect to both X_1 and X_2. The expression obtained shows that if ripples are superimposed on a coarsely uneven surface, then additional scattering is obtained, whereas, as is well known, small regular ripples on a plane surface do not produce any scattering, if the wave length of the ripples is less than that of the sound.

The above theoretical treatment is of general significance and can be applied to electromagnetic waves.

Marie Goyer, England

539. **Hartmann, J., and Larris, F., The air-jet generator as a means for setting up waves in a liquid medium,** *K. danske Vidensk. Selsk. Mat. Fys. Medd.* **26,** 11, 26 pp., 1951. $0.75.

An air-jet generator, a very simple and inexpensive means of generating acoustical energy in air, transmits its energy into water with a theoretical efficiency of only 0.34% when operated at an excess pressure of 3 kg/cm². The true efficiency is still lower, since the oscillator and liquid are separated by a phosphor-bronze membrane, the thinness of which is a compromise between life expectancy and high energy in the liquid. The energy is about 1.8 W/cm² and can be compared with a quartz oscillator of medium size. Author points out the difficulties in measuring the absolute sound energy caused by annular waves on the membrane. Device is used to obtain emulsions and to study biological effects in analogy to experiments with quartz oscillators.

Margot Herbeck, Germany

540. **Velichkina, T. S., and Fabelinskiĭ, I. L., Method for measuring the ultrasonic wave velocity in liquids** (in Russian), *Doklady Akad. Nauk SSSR (N.S.)* **75,** 2, 177–180, Nov. 1950.

Ultrasonic signals are passed through a glass rod, a thin layer of liquid, and a second glass rod where their intensity is observed by means of an optical method and, independently, a piezo-quartz detector. The (half) wave length is found by determining the increment of the layer thickness that lets the intensity vary from one maximum to another maximum. Measurements of this kind are insensitive toward the viscosity of the liquid and may be carried out with small samples and in wide ranges of the temperature. Results: The wave velocity in pentane varies between 2 and −120 C from 1.05 to 1.80 × 10³ m/sec; in triacetine it varies between 90 and −30 C from 11.5 to 15.5 × 10³ m/sec, whereas the viscosity increases by a factor 10⁴. The frequency is 2.5 × 10⁶ sec⁻¹; the wave-velocity temperature graphs are linear.

R. Eisenschitz, England

Ballistics, Detonics (Explosions)

(See also Rev. 494)

541. **Ghilini, J., Study of spherical triangles and of their applications** (in French), *Mémor. Artill. fr.* **25,** 1, 91–101, 1951.

Several well-known relations in spherical trigonometry are simplified by expansion in power series. These results are approximately correct for spherical triangles having a small polar angle. The error introduced by the use of these approximate expressions is calculated for some special cases, and application of the resulting equations to problems of navigation and aiming of guns is discussed.

Morton Alperin, USA

542. **Davies, R. M., Owen, J. D., and Trevena, D. H., The measurement of the velocities of bullets with a counter chronometer,** *Brit. J. appl. Phys.* **2,** 9, 270–271, Sept. 1951.

Projectile velocities are measured by a microsecond counter chronometer which is triggered at the beginning and the end of the interval by pulses produced when the bullets intercept two parallel pencils of light falling on two photocells. Paper presents minor modifications of a standard ballistics method for use with a short (20 cm) base line.

Lucien M. Biberman, USA

543. **Tsien, H. S., and Evans, R. C., Optimum thrust programming for a sounding rocket,** *J. Amer. Rocket Soc.* **21,** 5, 99–107, Sept. 1951.

For a constant effective exhaust velocity and for constant value of the gravitational acceleration, the optimum time variation of the thrust (optimum thrust programming) is calculated by the use of variational calculus. The height to be reached and the final weight of the sounding rocket are specified in advance. A set of three partial differential equations is found as the solution of the variational problem. One of these equations is for the aerodynamic drag. If the drag is specified, the trajectory of the rocket can be evaluated as a function of time, as well as the optimum thrust variation with time for any specified case. Two special cases are treated. In the first, it is assumed that the aerodynamic drag varies with the square of the velocity, while in the second, a linear variation of the drag with velocity is assumed. In both cases, an exponentially diminishing air-density law is assumed. It is shown that a finite value of boosting velocity is needed in any case (impulsive start). For optimum programming the thrust should increase with altitude, after initial boosting. Several constant-thrust rockets are compared with the calculated ideally programmed rockets. The results are presented in graphical form. These graphs can serve for the evaluation of optimum thrust programming once the altitude to be reached and the final weight of the rocket are given.

Paul Torda, USA

544. **Summerfield, M., A theory of unstable combustion in liquid propellant rocket systems,** *J. Amer. Rocket Soc.* **21,** 5, 108–114, Sept. 1951.

The low frequencies which are sometimes observed during oscillatory combustion in liquid-propellant engines are analyzed on the hypothesis that they are produced by a delay between the time the gas enters the combustion chamber and the time at which evolution of gases is essentially completed. The time delay is assumed to be constant for any given system and, in particular, it is taken to be independent of the instantaneous pressure in the combustion chamber. The assumed model leads to the conclusion that regions of stable and unstable combustion exist. Stability can be achieved by increasing the length of the feed line, the ratio of feed pressure to chamber pressure, the ratio of chamber volume to nozzle area, or by reducing the length of the combustion delay.

The analysis is concerned only with the low-frequency oscillations associated with motor "chugging" and is not meant to explain acoustic vibrations. It differs from the work of other investigators by taking into account the chamber capacitance, as well as the feed-line inertia, in computations of the effect of changing chamber pressure on propellant flow.

S. S. Penner, USA

Soil Mechanics, Seepage

545. Haefeli, R., Development and problems of soil mechanics (in French), *Minist. Obras Públ., Lab. Engen. civ. Lisbon Publ.* 14, 21 pp., 1951.

Paper is reprint of talk given to civil engineers to familiarize them with soil mechanics. Very interesting paper but nothing in it for a researcher in the field. Robert Quintal, Canada

546. Dubrow, G. A., Evaluation of the stability of hydraulic structures and the allowable soil pressure (in German), *Planen u. Bauen* **5**, 18, 418–422, Sept. 1951.

Paper offers an extension of the classical solution for the load-bearing capacity of a semi-infinite soil mass subjected to uniformly distributed normal forces on an infinitely long strip [Prandtl, *Z. angew. Math. Mech.* **1**, 1, p. 15, 1921]. The solution is extended to cover the case of oblique loading and thus broadens its field of applicability to problems of stability of retaining walls and dams. As an added refinement, the weight of the sliding soil masses is included in the stability computations.

Oscar Hoffman, USA

547. Blum, H., Simplified determination of earth pressure coefficients (in German), *Bautechnik* **28**, 8, 180–184, Aug. 1951.

One of the problems in designing earth-retaining structures is the determination of the earth pressure. Author presents tables and nomograms for determining active and passive earth pressures of cohesionless soils on the basis of Coulomb's theory. This theory is based on the simplifying assumption that the inclined boundary of the sliding wedge is plane. More rigorous solutions indicate that this assumption is reasonable for active earth pressure on a smooth wall. For a passive pressure on a rough wall, however, especially where the angle of skin friction is large, the rupture surface is curved and leads to a considerably smaller resistance than that obtained on the basis of a plane surface. In that case, Coulomb's theory and corresponding results by author are on the unsafe side and should be replaced by more rigorous methods of computation. G. G. Meyerhof, England

548. Rodin, I. V., On the solution of problems concerning the gravitational pressure of a mountain mass on the shoring of underground excavations (in Russian), *Doklad*i *Akad. Nauk SSSR (N.S.)* **78**, 3, 421–424, May 1951.

This is a continuation of the paper reviewed in AMR **5**, Rev. 283. The deformations of the original periphery of the tunnel produced by the removal of the supporting rock during the tunnel construction are taken to equal the deformations of the rock mass due to the reaction pressures of the shoring plus the deformations of the shoring itself. The above relationships are defined and equations are given which permit the determination of the normal and of the tangential pressures on the shoring from these deformation relationships and the yield coefficients of the shoring and of the rock mass. Gregory P. Tschebotarioff, USA

549. Anonymous, Procedures for testing soils, *Amer. Soc. Test. Mat.*, 418 pp., July 1950. $3.75.

Book compiles, in one handy reference volume, many of the procedures for sampling and testing of soils used by a number of important laboratories throughout the country. Tests for soils accepted as tentative or standard by the American Society for Testing Materials are included, together with suggested modifications thereof. Suggested procedures are also given for practically all common types of soil tests. The procedures are grouped into five categories, each pertaining to a particular phase of soil testing: Part I, Soil explorations and sampling of soils; Part II, Physical characteristics and identification of soils; Part III, Physical and structural properties of soils; Part IV, Special construction control tests for subgrades and base courses of highways and airports; for stabilization of soil with admixtures of soil, cement, bituminous and chemical materials for earth dams and embankments; Part V, Bearing-capacity tests of soils in place and dynamic properties of soils.

The main introduction and the introductory paragraphs of the separate parts cover the uses and limitations of soil tests in a most commendable manner. The research nature of most soil testing today is emphasized, as are the difficulties of relating soil test results to field conditions. These introductory paragraphs should be required reading for any engineer associated with soil-mechanics testing. Part I is directed principally toward highway and airport work. A more comprehensive treatment of explorations for embankment or foundation projects would make this part of more general application.

Many of the test procedures presented, particularly the standard ones, are well known and widely used. A number of the suggested procedures are excellently prepared; however, the different procedures and suggested modifications presented for some of the tests are difficult for even an experienced soils engineer to evaluate. In many cases it is not quite apparent what benefits would be derived from the modifications to various standard test procedures. It would have been most helpful to have had clarifying notes or discussions regarding the intent of revisions to aid the serious reader. However, reviewer recognizes that this might be outside the scope of the committee preparing this volume without a large amount of comparative testing on which to base an opinion.

It is also unfortunate that "standard" test procedures used by a number of major soils laboratories have not been included. This is not a reflection on the committee which prepared the book, since nearly every individual laboratory has its own special apparatus and procedures for performing soil tests; the task of assembling the voluminous information included in the book undoubtedly has been a difficult one. However, it is regrettable that more cooperation was not obtained from some of the well-known agencies engaged in soil testing.

The book is a valuable addition to the library of anyone engaged in soil-testing work. Woodland G. Shockley, USA

550. Küper, F. M., Soil failure, *Cienc. y Técn.* **117**, 590, 591: 66–85, 97–123; Aug., Sept. 1951.

Pressures beneath foundations are determined according to two independent conditions: (a) Security against rupture caused by lateral flow of soil beneath foundation; and (b) security against excessive settlements. Present article deals exclusively with the first of these conditions, treating shallow, continuous footings with vertical or inclined loads, as well as square and circular footings. It gives the solutions found for these problems in Europe and America, which have a common origin in L. Prandtl's work, "Ueber die Haerte plastischer Koerper" (1920). These investigations, which due to World War II were conducted practically independently, not only offer a good comparison regarding their exactness, but also complement each other fruitfully. Author contributes new formulas for continuous shallow footings, with eccentric vertical loads, as well as for rectangular footings with centered vertical loads. Eckhardt Rathgeb, Argentina

551. Aitchison, G. D., and Butler, P. F., Gypsum block moisture meters as instruments for the measurement of tension in soil water, *Austral. J. appl. Sci.* **2**, 2, 257–266, June 1951.

The gypsum-block moisture meter has been suggested as an alternative to the tensiometer for the in situ measurement of an

extended range of moisture tensions. From laboratory studies of gypsum blocks in a pressure membrane apparatus it has been established that characteristic relationships exist between soil-moisture tension and block resistance for each of three types of blocks. Within each group of blocks it has been demonstrated that the resistance-tension relationship of an individual block is normally parallel to, although not coincident with, the mean curve for the group; and that this curve approximates a straight line over a large part of the sensitive range of the block.

It is concluded that gypsum blocks can be used to measure tension in the soil water within a range of $pF = 2.4$ to $pF = 4.2$ without undue complications from unavoidable block or soil variability. From authors' summary by John C. Geyer, USA

552. **Riordan, M. B., Surface indicating pressure, temperature and flow equipment,** *J. Petr. Technol.* **3** (*Trans.* **192**), 9, 257–262, Sept. 1951.

A surface indicating pressure, temperature, and flow instrument that employs variable frequency-sensing elements has proved useful in evaluating flow characteristics of wells. Relative productivity of individual oil and gas sands in a given well can be analyzed at several back pressures.

The variable frequency-sensing elements are an improvement in sensitivity and accuracy and make possible observation of temperature and pressure variations that have not been possible heretofore. The surface indicating feature results in a more direct approach to solving problems and eliminates many assumptions. All three subsurface factors are evaluated, and correlation between them results in a direct means of analyzing reservoir and well conditions.

Surveys have been used to evaluate well performance, locate gas entry in high ratio wells, and to investigate gas injection and water-flooding conditions. From author's summary

553. **Tompkin, J. M., and Britt, S. H., Landslides: a selected annotated bibliography,** *Nat. Res. Counc. Highway Res. Board, Bibliography* no. 10, vi + 53 pp., 1951.

554. **Cambefort, H., The flow of liquids through porous media,** *Wwys. Exp. Sta. Transl.* 51-3, 14 pp., 1951.

Paper reports laboratory-scale permeability tests which were made to assist in the interpretation of pumping tests in a filter well. Permeability tests were reported on three gravels and two sands which had relatively uniform grain-size distribution. All specimens were artificially prepared. Author showed that the range of applicability of Darcy's law to saturated flow in gravels is bounded by both upper and lower limits, the former being the rate of flow where the transition from laminar to turbulent flow occurs and the latter being a small rate of flow but different from zero. The data presented on sands were inconclusive in this respect.

Author attempts to generalize his data by study of two logarithmic plots of a Reynolds number vs. a friction factor. He uses two different definitions of the length dimension in Reynolds number to characterize the grain-size distribution of the specimens and two different definitions of velocity. Neither of the plots results in a general conclusion. Donald M. Vestal, Jr., USA

Micromeritics

555. **Tarján, G., Mechanics of the cyclone** (in Hungarian), *Bányászati és Kohászati Lapok = Hung. J. Mining Metall.* **5** (**83**), 11, 610–614, Nov. 1950.

Author investigates the laws of kinetic phenomena in cyclones, which are utilized in dust-removal equipment for gas, in washing apparatuses for minerals, in concentrators, in separators, and slime thickeners. The number of whirls, as well as the length of time the gas remains in the dust-removing tubes of the cyclone, are determined for the various cyclones and grain diameters. The investigations were extended to the washing of coal in order to reduce the ash content of fine-grained coal and to the separation of slime suspensions, which contain minerals of varying specific gravity. In the event slimes do not contain heavy suspensions, cyclones act as effective slime thickeners, and the thick slime flowing from the discharge openings may contain as much as 70 to 80% of the solid particles contained in the raw slime. The calculations are based on Stokes' viscosity values, which, however, require corrections in the function of the Reynolds number according to the curve $c = f(R)$.

Courtesy Hungarian Technical Abstracts

Geophysics, Meteorology, Oceanography

(See also Revs. 356, 465)

556. **Anonymous, The results of marine meteorological and oceanographic observations,** *Centr. meteor. Observ. Japan, Tokyo* no. 3, 256 pp., no. 4, 414 pp.; Jan.-June, July-Dec. 1948, published 1951.

557. **Ichie, T., A note on the effect of inertia terms upon the drift currents,** *Oceanogr. Mag. Centr. Meteor. Observ., Tokyo*, **2**, 2, 41–48, June 1950.

The effect of the nonlinear inertia terms on wind drift current is shown to be small in the open sea, but not necessarily small near shore. This agrees with conclusions reached by the reviewer [*J. mar. Res.* **9**, 3, 218–238, Dec. 1950].

Walter H. Munk, USA

558. **Arons, A. B., and Stommel, H., A mixing-length of tidal flushing,** *Trans. Amer. geophys. Un.* **32**, 3, 419–421, June 1951.

The salinity distribution is computed for an idealized estuary where mixing is predominantly due to the tides, using an eddy diffusivity based on the distribution of tidal currents and excursions. Comparison is made of the salinity distribution in real estuaries.

From authors' summary by Walter H. Munk, USA

559. **Robitzsch, M., Temperature of fog droplets** (in German), *Z. Meteor.* **4**, 12, 353–356, Dec. 1950.

Author regards cloud and fog droplets as little wet bulbs. Their temperature, accordingly, is the wet-bulb temperature (as given by the psychrometer equation) corresponding to the temperature and humidity of the surrounding air. If the effect of surface tension on the vapor pressure outside the highly curved surfaces of the droplets is then taken into account, it appears that the droplet temperature is always less than that of the air. This is so even when the surroundings are saturated relative to a flat surface (such as a hygrometer). It is thus unnecessary to postulate (as is often done) supersaturation in the ambient air, a condition never unambiguously observed in clouds.

Some representative values of the temperature defect of the droplets are listed. At 750-mm mercury atmospheric pressure, and at 0 C, for instance, a 1-micron radius droplet is computed to have a temperature of −0.63 C, a 0.1-micron droplet a temperature of −5.92 C. At lower atmospheric pressures, the effect appears to be even more pronounced.

Reviewer believes that the effect is much smaller than cal-

culated in this paper; author's numerical application of Kelvin's well-known theory of the curvature effect on vapor pressure seems to be in error. The values listed by him of the vapor pressure above a curved surface are greatly in excess of those generally accepted, e.g., the values given by N. K. Adam ["Physics and chemistry of surfaces," Clarendon Press, 1930] or G. Simpson [*Quart. J. roy. meteor. Soc.*, **67**, 99–133, 1941].

Walter Hitschfeld, Canada

560. Otani, T., Kanzai, S., Fujiwhara, S., and Syono, S., On the behaviour of two coupled vortices and velocity distribution within them, *Geophys. Mag. Tokyo* **22**, 4, 289–310, Aug. 1951.

Paper describes water-tank experiment made at Tokyo University during 1926–27. Dual vortexes were mechanically maintained, and the interaction between the fields of rotation of vortexes of the same and opposite sign was studied by photographing the paths of floating aluminum or paper tracers. In general, the findings are in agreement with classical hydrodynamics—attraction between vortexes of opposite signs and repulsion between vortexes of the same sign. However, in some cases attributed to turbulence, the opposite effect was noted in that vortexes of the same sign tended to amalgamate and to become stronger. Quantitative expressions of the attraction and repulsion are tabulated.

The mathematical discussion is principally a kinematic formulation of the results. There is no attempt to treat the dynamics of the system.

Herbert Riehl, USA

561. Czepa, O., On the night-cooling of the earth's surface and of the air layer near the earth (in German), *Z. Meteor.* **4**, 12, 359–362, Dec. 1950.

Formulas for calculating nocturnal temperature changes at ground are summarized. Elsasser diagram and Ångstrom formula (with Bolz and Falckenberg constants) give nocturnal radiation (*Gegenstrahlung*) in reasonable agreement with Sauberer's measurements. Net outgoing radiation decreases, on the average, 12 to 15% in course of night, but decrease may reach 30 to 35% on unusual (presumably dry) radiation nights (*ausgesprochenen Strahlungsnächten*). Elsasser diagram calculations from means of Lindenberg ascents show 72% of total nocturnal radiation originated from lowest 87 m of atmosphere; temperature variation of 5 C changes nocturnal radiation by 5%. Higher levels are much less effective. Reviewer believes layer too thin by factor of 2.5 [*Quart. J. roy. meteor. Soc.* **76**, p. 489, 1950].

Lewis Kaplan, USA

562. Graf, A., A new measuring and recording instrument for microbarometric investigations, especially for height measurements (in German), *Z. angew. Phys.* **3**, 3/4, 107–110, 1951.

Paper describes microbarometer using Bourdon spiral as sensing element. Rotational motion of free end of spiral is detected by optical lever, thus eliminating all friction. Scale sensitivity is 0.1 mm Hg, with range of 300 mm Hg, coverable in steps (manual resetting of coarse adjustment required). Eddy-current or hydraulic damping may be employed. Sensing element is supported in such manner as to minimize sensitivity to shock, vibration, or tilting. Bourdon element is temperature-compensated by partial filling with dry air. Comparison tests with precision aneroid show advantages of new instrument; a series of measurements on a five-story staircase surveyed with a tape measure gives mean error of 0.08 cm of height (0.008 mm Hg pressure difference) for new device, as compared to 0.48 cm height (0.048 mm Hg) for aneroid. Author claims negligible hysteresis errors. Instrument may be coupled to photoelectric recorder to form precision microbarograph.

Reviewer believes elimination of friction by optical lever constitutes valuable improvement, but cannot agree with author that new device possesses such great stability of calibration as to permit its use in place of mercury barometer in weather stations. Reviewer agrees with author that device is useful as field instrument (weight 3 kg) for surveyors, explorers, and cartographers, and constitutes an improvement over existing aneroids.

Earl W. Barrett, USA

563. Sutcliffe, R. C., The quasi-geostrophic advective wave in a baroclinic zonal current, *Quart. J. roy. meteor. Soc.* **77**, 332, 226–234, Apr. 1951.

Paper outlines a simplified theory relative to advective waves in a baroclinic zonal current. The approach differs somewhat from an earlier development of the subject by Rossby, but with certain limiting assumptions yields similar results. Of interest is the discussion of the wave-speed equation and conditions of baroclinic stability. The theory or "model" proposed by author simplifies actual conditions but serves well tô illustrate the kind of instability associated with atmospheric circulations on a synoptic scale. The mathematical treatment based on earlier papers by author is both clear and direct.

J. M. DallaValle, USA

Lubrication; Bearings; Wear

564. Rabinowicz, E., and Tabor, D., Metallic transfer between sliding metals: an autoradiographic study, *Proc. roy. Soc. Lond.* (*A*), **208**, 1095, 455–475, Sept. 1951.

The amount of material transferred from a surface of radioactive metal on sliding over a nonradioactive surface was indicated by autoradiography. Rubbing surfaces included copper, cadmium, zinc, platinum, and various steels. Effective lubrication of surfaces reduces friction by a factor not exceeding 20, while the amount of metal transferred is diminished by a factor of 20,000. Thus, when lubrication is effective, the work expended in rupturing junctions between the surfaces contributes only slightly to the frictional resistance.

Paper brings out the important qualitative fact that transfer of metal during sliding occurs in discrete fragments. Reviewer feels, however, that the quantitative evidence is insufficient basis for some of the generalizations in the paper.

F. T. Barwell, Scotland

565. Burwell, J. T., The calculated performance of dynamically loaded sleeve bearings. III, Ann. Meeting Amer. Soc. mech. Engrs., Atlantic City, 1951. Paper no. 51—A-7, 12 pp. = *J. appl. Mech.* **18**, 4, 393–404, Dec. 1951.

Paper extends author's previous calculations to limiting case where sleeve bearings are so narrow that the following basic assumption seems justifiable: circumferential film flow is negligible in comparison with transverse film flow (side leakage).

The corresponding performance of the narrow bearings, which is also expressed in terms of the loci of the journal center, is calculated for various simple types of dynamic loading; constant loading in fixed direction is also considered. This performance proves to be qualitatively similar to that of the other limiting case of infinitely wide bearings, where transverse film flow may be neglected altogether. Accordingly, author expects bearings of arbitrary width qualitatively to perform in a similar way.

However, in contrast to author's opinion, under operating conditions where journal eccentricity ratio is sufficiently great (minimum film thickness sufficiently small), even very narrow bearings will perform like infinitely wide bearings in that their circumferential film flow becomes preponderant; then author's basic assumption is violated. The reason is that the formation

of film pressures then tends to confine itself to that region of the film where its thickness is at a minimum. Accordingly, author's results, when extrapolated toward eccentricity ratios approaching unity, are no longer reliable. For great eccentricity ratios the theory by Cameron and Wood [AMR **3**, Rev. 2559], which however relates only to constant loading in fixed direction, is to be preferred, because it reduces to the theory of infinitely wide bearings.

H. Blok, Holland

Marine Engineering Problems

566. **McMullen, J. J., Selection and design of a gas turbine and investigation of its adaptability for the propulsion of a freighter** (in German), Thesis, Inst. therm. Turbomasch., *ETH Zürich, Mitt.* 1, 109 pp., 1950.

Writer makes a fairly detailed investigation of the problems of adapting gas turbines to freighter use. The subjects discussed are, after selection of a typical vessel, the following: Choice of propeller, considerations of open and closed turbine cycles, the heater for the working gases, compressor and turbine dimensions and characteristics, and the design of heat exchangers for the open cycle.

Following this, and on the basis of the previous considerations, the closed cycle is selected as being the best choice. Some advantages of closed cycles are mentioned: Smaller stacks needed, pure working fluid, better part-load efficiency, better regulation characteristics, possibility of using a variety of working gases, and better development prospects.

A rather detailed discussion of closed-cycle requirements and constructional details is then given, together with a shorter section on some part-load and regulation problems.

While some readers may feel that their specialties are not treated in enough detail or else are oversimplified, reviewer believes that the over-all problem has been quite well treated and has resulted in an interesting and useful article.

Bruno W. Augenstein, USA

567. **Ayre, A. L., Resistance and propulsion,** *Engineering* 171, 4456, 4457; pp. 767, 800–802; June 1951.

Author states: "One of the main reasons for the presentation of this paper is to be found in the unrest in the minds of some of those who undertake the ultimate and contractual responsibility for the speed and power of ships." From that point of view the applicability of model tests is discussed. A universal basis for determination and presentation of data is recommended. From his rich experience, author gives valuable advice concerning the influence of several features: Length, speed, block coefficient, bilge radius, angle of entrance, rake of stem, and, for the propeller, location and clearances in the aperture, relationship of diameter to breadth and form of the hull, revolutions, adoption of airfoil sections, reduction of pitch toward the blade roots, washback at the trailing edge of the face. Graphs comparing results from trials of ships and model series with standard values are given and some abnormally good results discussed.

Einar Hogner, Sweden

568. **Dorey, S. F., Stresses in propellers and propeller shafting under service conditions,** *Trans. N. E. Coast Instn. Engrs. Shipb.* **67**, part 8, 389–426, Aug. 1951.

Paper gives the various conditions of vibratory stress in marine propellers and shafting, their purported cause and effect, and methods of measurement developed by Lloyd's.

Author describes in detail and analyzes several cases of repeated tail-shaft or propeller failures in particular classes of ocean-going vessels. A detailed breakdown of various known and suspected causes for these and related failures is given. The appendix includes calculations of blade root stresses in steady and vibratory load.

James B. Duke, USA

569. **Romsom, J. A., Strength calculation of marine propellers** (in Dutch), *Schip en werf* **18**, 20, 394–400, Sept. 1951.

Taylor's calculation of strength of propeller blades in "Speed and Power of Ships" is reviewed briefly and its shortcomings mentioned. A revision is attempted, with thrust and torque based either on Wageningen propeller B-series or on circulation theory. Bending moments caused by thrust and torque are about the same as obtained by Taylor at 0.2 radius, but about 10% less at 0.6 radius. Taylor's geometrical coefficients for moduli of blade sections are substituted by coefficients obtained by measurement of strain. Only one such measurement is quoted, made on a B 4.40 Wageningen propeller. Author emphasizes necessity of more measurements, e.g., on propellers with larger blade areas. For normal pitch ratios, results are not far from Taylor's at 0.2 R except at great slip. Author recommends a maximum permissible stress of 450 kg/cm^1 in tension corresponding to 500 kg/cm^2 in compression, for manganese bronze.

Georg Vedeler, Norway

570. **Guilloton, R., Potential theory of wave resistance of ships with tables for its calculation,** *Trans. Soc. nav. Archit. mar. Engrs.* 38 pp., 1951.

Paper consists of three related articles. Foreword by Korvin-Kroukovsky reviews use of velocity potential in computation of ship-wave resistance and outlines theories used in main part of paper. Guilloton, in main article, reviews briefly the concept of tangent potential discussed extensively in many of his previous papers. In place of Havelock's method of combining sources and uniform flow to represent the shape of the body, Guilloton's method builds up the body of a series of wedges, the potential of which he has computed. Thirty-one tables for use with this method are presented along with descriptions for their use. An appendix to this part gives the relations between the potential defined by the tables and that of Havelock's sources. In third article, Wigley presents an extensive bibliography of papers on ship-wave motion. Author considers that the tables are the most important part of the paper. These are designed primarily for use by the naval architect in evaluating wave-making resistance. Reviewer believes that the method would be simpler to use and easier to understand if dimensionless parameters were used.

W. D. Baines, Canada

571. **Weinblum, G. P., The thrust deduction,** *J. Amer. Soc. nav. Engrs.* **63**, 2, 363–379, May 1951.

Paper gives simple description of theoretical methods used in research on thrust deduction, and sketches state of knowledge so far reached. Author states that application of source and sink concept to ship and propeller system leads to satisfactory explanation of thrust deduction. However, quantitative agreement between theory and facts is still wanting. Paper is based essentially on Dickmann's classical work.

Manley St. Denis, USA

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